June 2001
Manitoba Conservation Report No. 2001- 02

A WATER QUALITY ASSESSMENT OF COOKS CREEK, MANITOBA, CANADA, 1990 to 1999

C. E. Hughes
Water Quality Management Section
Manitoba Conservation

Manitoba
Conservation

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102-00117/

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Summary

Water quality monitoring on Cooks Creek was undertaken jointly by the Cooks Conservation District and the Province of Manitoba beginning in 1990. Two sites have been monitored routinely from 1990 through 1999 including a site near Millbrook and a downstream site at the boundary of the rural municipalities of Springfield and St. Clements.

Comparisons between the upstream and downstream sites indicated significantly higher concentrations of total phosphorus, as well as conductivity and the related total dissolved solids at the downstream site. Some of the additional phosphorus and dissolved solids can be attributed to discharges of treated sewage from Oakbank but also may be due partly to the diversion of some of the upstream water during high water periods which might have provided more dilution. Fecal coliform bacteria, and suspended solids concentrations were significantly higher at the upstream site. The higher fecal coliform bacteria densities at the upstream site appeared to be due largely to livestock operations. The upstream site is located in a channelized portion of the creek and the potential for scouring was probably greater than in the deeper natural meanders of the creek at the downstream site.

Data for 25 variables from the downstream site were used in the calculation of the Canadian Water Quality Index (CWQI). The only water quality objective to be consistently exceeded was total phosphorus. This is fairly typical of most prairie streams, which tend to be nutrient rich. Water quality in Cooks Creek is generally acceptable for most purposes.

Évaluation de la qualité de l'eau du ruisseau Cooks (Manitoba, Canada) de 1990 à 1999

Résumé

En 1990, le district de conservation du ruisseau Cooks et le gouvernement du Manitoba ont entrepris, en collaboration, la vérification de la qualité de l'eau du ruisseau Cooks. De 1990 à 1999, on a procédé à la vérification régulière des eaux provenant de deux sites, notamment un site près de Millbrook et un site en aval, se trouvant à la limite des municipalités rurales de Springfield et de St. Clements.

En comparant les sites en amont et en aval, on a constaté, au site en aval, des concentrations beaucoup plus élevées de phosphore total, ainsi que l'existence d'une conductivité et des matières totales dissoutes qu'elle entraîne. Certains des phosphores et des matières dissoutes supplémentaires peuvent surtout être attribués à l'évacuation des eaux usées traitées d'Oakbank. Cependant, ils peuvent aussi être attribués en partie au détournement de certaines eaux en amont pendant les périodes de crue, ce qui aurait pu entraîner une dilution accrue. En amont, on a relevé une présence très importante de coliformes fécaux et de matières en suspension. Ces fortes densités seraient principalement causées par les activités d'élevage. De plus, puisque le site en amont se trouve dans une partie canalisée du ruisseau, cela peut entraîner un effet de chasse beaucoup plus important que dans les méandres naturels et profonds du ruisseau, où se trouve le site en aval.

Dans le calcul de l'indice canadien de la qualité des eaux, on a utilisé des données portant sur 25 paramètres de l'eau du site en aval. Le seul critère de qualité de l'eau qui n'était pas respecté était la quantité de phosphore total, qui était toujours excédentaire. Cela est assez caractéristique de la plupart des ruisseaux des prairies qui sont généralement riches en substances nutritives. La qualité de l'eau du ruisseau Cooks est généralement acceptable en ce qui concerne la plupart des usages.

A Water Quality Assessment of Cooks Creek, Manitoba, Canada, 1990 to 1999

INTRODUCTION

A water quality study on Cooks Creek was undertaken jointly by the Cooks Creek Conservation District and the Province of Manitoba beginning in 1990. Data up to July 1993 were reported by Hughes *et al.* (1994) and more recent data were described in a brochure. District staff have sampled water at several sites in recent years. However, sampling has been conducted for the entire 10-year period from 1990 through 1999 at two sites, one located 1.6 km south of PTH 44, and the other located 4.8 km south of PTH 15 (Figure 1). Sampling for a complete range of variables has only been conducted at the downstream site near PTH 44. The objective of this report is to utilize a water quality index to show annual trends or changes in water quality over the past decade. Comparisons for some variables including bacteria, dissolved and suspended solids, pH, dissolved oxygen and nutrients identify differences between upstream and downstream locations that may have occurred due to direct or indirect discharges.

Drainage Basin Characteristics

Cooks Creek originates near Richer and drains in a northwest direction where it joins the Red River near Selkirk, Manitoba. The total drainage area is approximately 700 km^2 (Water Survey of Canada 1993).

Within the study area a considerable portion of Cooks Creek has been dredged to the point where natural contours no longer exist (Figure 1). During periods of high flow, the Cooks Creek Diversion channel diverts approximately half of the flow from the upper drainage area upstream of and including Edie Creek. During periods of low flow, little water is diverted and most of the water flows down Cooks Creek to the Red River (Lussier, pers. comm.[1]). The portion of Cooks Creek from immediately upstream of Cooks Creek community and the remaining portion of Cooks Creek to its confluence with the Red River remains for the most part within its natural contours.

Surficial deposits are variable (Weir 1983). The major portion of Cooks Creek drainage basin lies within the central lowlands. Deep basin deposits consist of clay with some silt and sand. Beach and near-shore deposits form distinct ridges in the vicinity of Birds Hill. Further west, the main portion of Birds Hill consists of glaciofluvial deposits of sand and gravel. The uplands to the east of Edie Creek and the upper portion of Cooks Creek (further upstream from Site WQ0644 as illustrated in Figure 1) include some till and a few beach and near-shore deposits. Near East Selkirk, surface deposits are glacial till. Underlying bedrock formations include limestone, sandstone, and bedrock of variable depths.

Soils in the area are mainly Black and Dark Grey Chernozemic (Weir 1983). Chernozoemic soil predominates in the central lowlands. However, some deposits of a combination of Fibrisolic, Mezisolic and Grey Luvisolic soils are found in the eastern uplands.

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[1] Lussier, B.M. Manager. Cooks Creek Conservation District.

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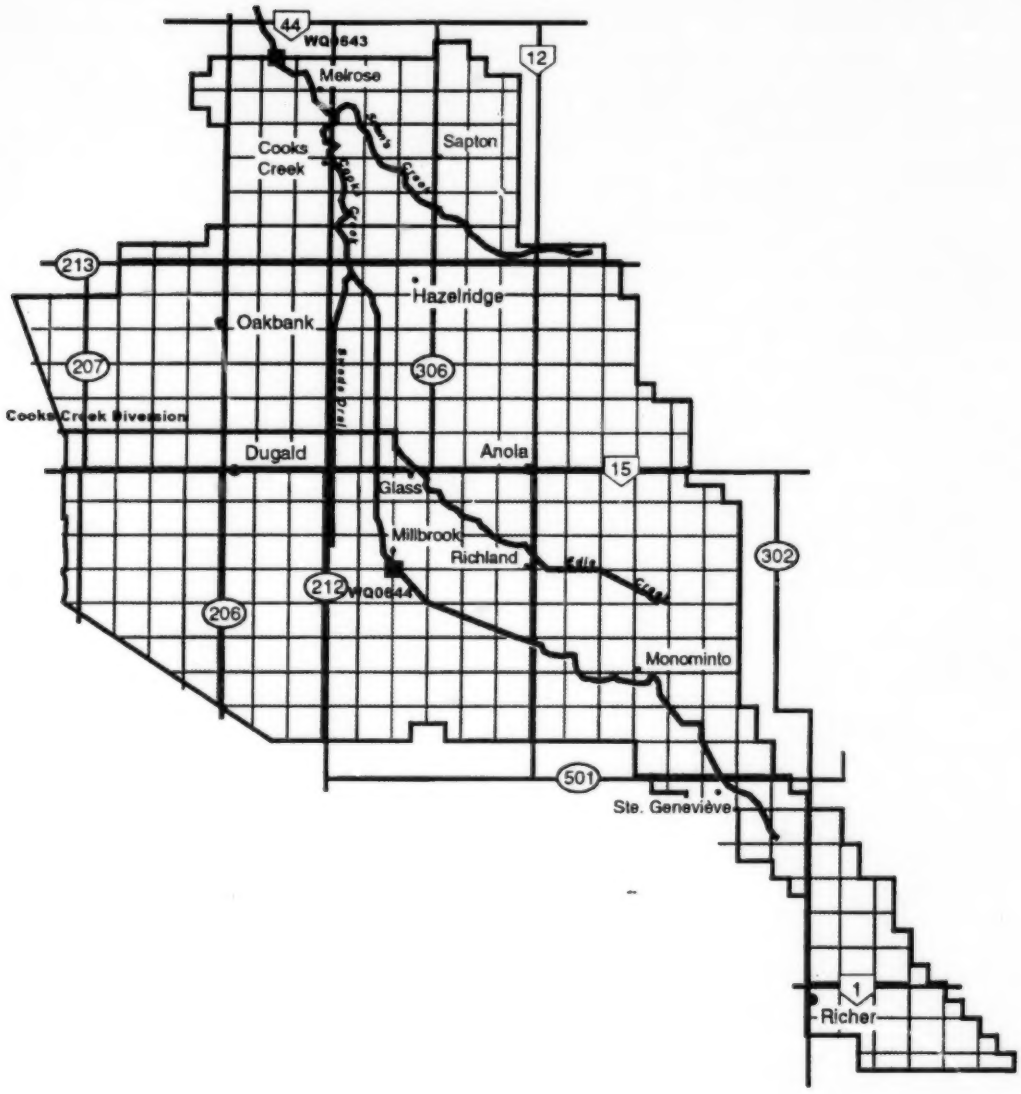

Figure 1. Cooks Creek Conservation District showing water quality sites WQ0643 and WQ0644.

The eastern upland region includes woodlands with some cultivated fields, pastures, and building sites. The lower region is now intensively cropped. Other land uses include some industry and the extraction of sand, gravel, and peat.

METHODS

Sample Collection and Analyses

Over the past decade water quality samples have been collected on a monthly basis from Cooks Creek site WQ0643 at the boundary of the rural municipalities of Springfield and St. Clements. Analyses for a wide range of variables were conducted on water samples collected from this site. These include bacteria, pH, dissolved and suspended solids, specific conductivity, turbidity, nutrients, dissolved oxygen, dissolved salts, trace metals, and pesticides. This site should show the cumulative effects of most of the factors that effect water quality. Although there are other water quality sites located upstream of this site they are currently only sampled during the summer months and analyses are currently limited to pH, dissolved and suspended solids, specific conductivity, turbidity, bacteria, nutrients, dissolved oxygen, and chlorophyll *a*. Cooks Creek site WQ0644 is the only other long-term water quality sampling site and it is located in a channelized portion of the creek near Millbrook. Comparisons between these two sites with respect to the smaller number of variables will demonstrate changes that may occur in variables such as bacteria, nutrients and dissolved solids in particular.

Analyses of water samples were conducted at the W.M. Ward Technical Services Laboratory and Cadham Provincial Laboratory and subsequently at Envirotest Laboratories.

Data Analyses

Twenty five variables were selected from the data set from Site WQ0643 to be used in calculation of a Canadian water quality index (CWQI) on an annual basis (CCME 2000). With the exception of the total phosphorus objective and total suspended solids objective taken from Williamson (1988), all other objectives were taken from Williamson (2000). For each of the variables the objectives are set for various water uses; the CWQI measures the relative effects of excursions from these objectives (Table 1). An excursion occurs when objectives are exceeded. The CWQI uses three functions with F_1 measuring the number of variables where excursions occur, F_2 measuring the frequency of excursions, and F_3 measuring the average departure of the excursions from the objectives.

Student's *t* paired difference analysis was used to determine whether there were significant differences (α =0.05) between the upstream and downstream sites for bacteria, pH, specific conductivity, total dissolved solids, total suspended solids, turbidity, dissolved oxygen, phosphorus, ammonia, nitrate-nitrite, and total nitrogen. Except for pH the remainder of the data were transformed to a logarithmic base to stabilize the variances.

RESULTS AND DISCUSSION

Objective Excursions and Canadian Water Quality Index

The CWQI rating for water quality was fair for all years except for 1998 when the rating was in the low end of the good range (Figure 2). The only water quality objective to be consistently exceeded was total phosphorus. The objective for total phosphorus is established at 0.05 mg/L which is a guideline above which there is potential for algae blooms and nuisance

levels of macrophyte (rooted aquatic plants) growth (Williamson 1988). The objective for aquatic life of 2.6 µg/L for the herbicide MCPA was used in CWQI calculations (Williamson 2001). The MCPA objective for aquatic life is the second lowest MCPA objective. If the irrigation water quality objective for MCPA of 0.025 µg/L were used then the magnitude of excursions would be such that the CWQI water quality ratings for 1993, 1994 and 1998 would be substantially lower. Also, the CWQI water quality ratings in 1993 and 1994 would have been marginal to poor and the 1998 CWQI rating would be fair and not good. Appendix 1 summarizes average annual means ranges and numbers of excursions from objectives for all variables for water quality data from Cooks Creek site WQ0643 at the boundary of the Rural Municipalities of Springfield and St. Clements.

Fecal Coliform Bacteria

Fecal coliform bacteria originate in the digestive tracts of warm-blooded animals, including birds and humans. Fecal coliforms are considered "indicator bacteria." They do not normally cause illness but their presence may indicate contamination by human or animal feces. Large numbers of fecal coliforms can be associated with disease causing organisms. All surface waters used for domestic consumption must receive a minimum level of treatment to ensure that harmful disease-causing organisms, including fecal coliforms, are absent. Because of this treatment requirement, comparison of ambient water quality data for fecal coliforms to the recreational water quality objective is more meaningful than comparison to the drinking water quality objective. The objective for protection of recreational uses such as swimming is 200 fecal coliform bacteria/100 mL of sample.

Annual average counts of fecal coliform bacteria in Cooks Creek at site WQ0643 at the boundary of the rural municipalities of Springfield and St. Clements were acceptable for all recreational water uses. Individual fecal coliform counts exceeded 200 bacteria/100 mL in only 8% of 91 samples collected from 1990 through 1999 (Appendix 1 and Figure 3). However, fecal coliform counts were significantly higher at the upstream site near Millbrook than at downstream site WQ0643. At site WQ0644 near Millbrook the fecal coliform counts exceeded 200 bacteria/100 mL in 31% of 72 samples collected during the same period (Figure 3).

The higher fecal coliform bacteria counts at the upstream site WQ0644 are likely to have originated from agricultural sources since livestock enclosures are frequently within the flood plain of Cooks Creek and cattle have access to the stream for watering purposes at some locations. There may also have been some input from run-off from fields fertilized with manure. There are no sources of effluent from towns or villages within this reach. This portion of the stream is channelized and generally shallow and is not particularly suited as wildlife habitat although bird or mammal wildlife may occasionally contribute fecal coliform bacteria. Since the fecal coliform bacteria are significantly lower at the downstream site, there does not appear to be an impact from the treated effluent from Oakbank that enters Cooks Creek via the Swede Drain.

pH

The pH was within the bounds of 6.5 and 9.0 required to support aquatic life in all 98 samples collected from the Cooks Creek downstream site WQ0643 (Figure 4), although 6% of the pH values were above the pH of 8.5 required for protection of drinking water (Appendix 1). At upstream site WQ0644 the pH of 9.0 was exceeded once and the pH of 8.5 was exceeded in 11% of 79 samples (Figure 4). There was no statistically significant difference in pH between these two sites.

Table1. Canadian water quality index (CWQI), water quality variables and objectives or guidelines (Williamson 2000, Williamson 1988) used to calculate CWQI ratings (CCME 2000).

Variables	Units	Objective* Value	Objective* Use
Fecal Coliform MF	Bacteria/100mL	200	Recreation
Ph	Ph Units	6.5-9.0	Aquatic Life
Specific Conductivity	uS/cm	1000	Greenhouse Irrigation
Total Suspended Solids	mg/L	25 (mid range)	Aquatic Life
Dissolved Oxygen	mg/L	5 (mid range)	Aquatic Life
Total or Extractable Cadmium*	mg/L	Calculation based on Hardness (7Q10)	Aquatic Life
Total or Extractable Copper*	mg/L	Calculation based on Hardness (7Q10)	Aquatic Life
Total Arsenic	mg/L	0.025	Drinking Water, Health
Total or Extractable Lead*	mg/L	Calculation based on Hardness (7Q10)	Aquatic Life
Dissolved Aluminum	mg/L	0.1 for pH >6.5	Aquatic Life
Total or Extractable Nickel*	mg/L	Calculation based on Hardness (7Q10)	Aquatic Life
Total or Extractable Zinc*	mg/L	Calculation based on Hardness (7Q10)	Aquatic Life
Total or Extractable Manganese	mg/L	0.05	Drinking Water, Aesthetic
Total or Extractable Iron	mg/L	0.3	Drinking Water, Aesthetic
Total Ammonia as N	mg/L	Calculation based pH and Temperature	Aquatic Life
Soluble or Dissolved Nitrate-Nitrite	mg/L	10	Drinking Water, Health
Total Phosphorus	mg/L	0.050	Nuisance Plant Growth
Dicamba	ug/L	0.006 where detectable	Irrigation
Bromoxynil	ug/L	0.33	Irrigation
Simazine	ug/L	0.5	Irrigation
2,4 D	ug/L	4	Aquatic Life
Lindane	ug/L	0.08	Aquatic Life
Atrazine	ug/L	1.8	Aquatic Life
MCPA	ug/L	2.6 where detectable	Aquatic Life
Trifluralin	ug/L	0.2	Aquatic Life

* Calculation based on dissolved metals and may slightly over estimate excursions.

CWQI (CCME 2000) category ranges: 95-100 Excellent; 80-94 Good; 60-79 Fair; 45-59 Marginal; 0-44 Poor

$CWQI = 100-(((F_1^2+F_2^2+F_3^2)^{1/2})/1.732)$

Scope $F_1 = ((\text{Number of variables with an objective not met})/(\text{Total number of variables}))\times 100$

Frequency $F_2 = ((\text{Number of samples with an objective not met})/(\text{Total number of samples}))\times 100$

Amplitude $F_3 = ((nse/(0.01nse + 0.01))$

Where *nse* is the normalized sum of test excursions:

$nse = (\text{Sum of excursions}_i)/(\text{Total number of tests})$

Where test values must not exceed the objective:

$\text{excursion}_i = (\text{Concentration}_i)/(\text{Objective}_j)$

Where test values must not fall below the objective:

$\text{excursion}_i = (\text{Objective}_j)/(\text{Concentration}_i)$

Where the objective is zero:

$\text{excursion}_i = \text{Concentration}_i$

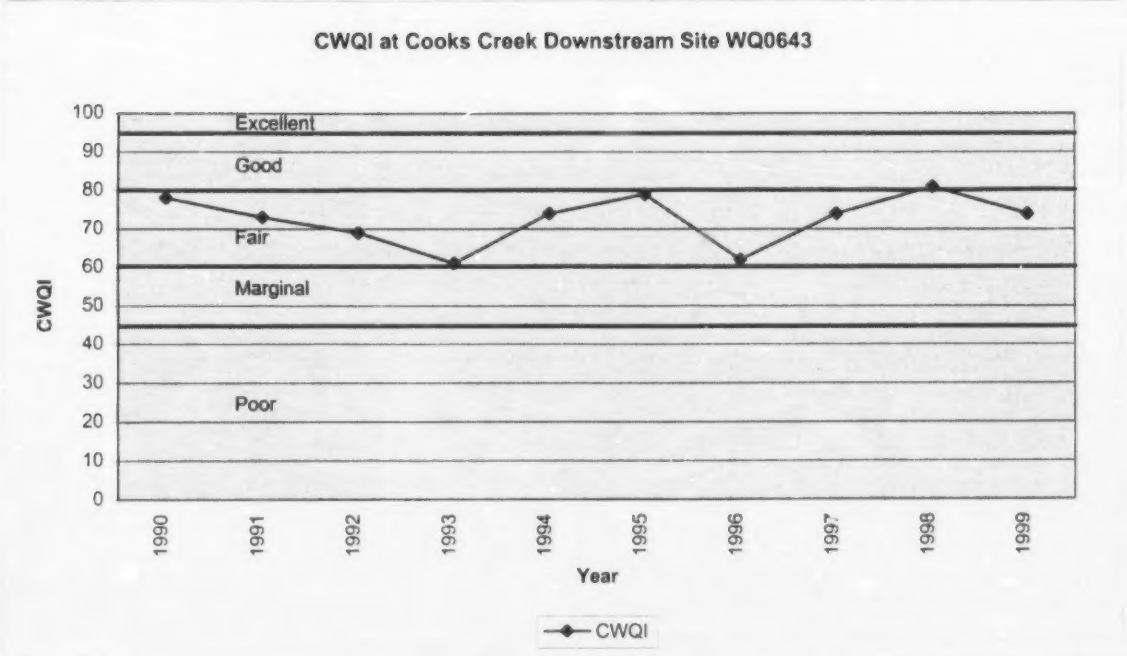

Figure 2. Cooks Creek Canadian water quality index (CWQI) at downstream Site WQ0643 on an annual basis.

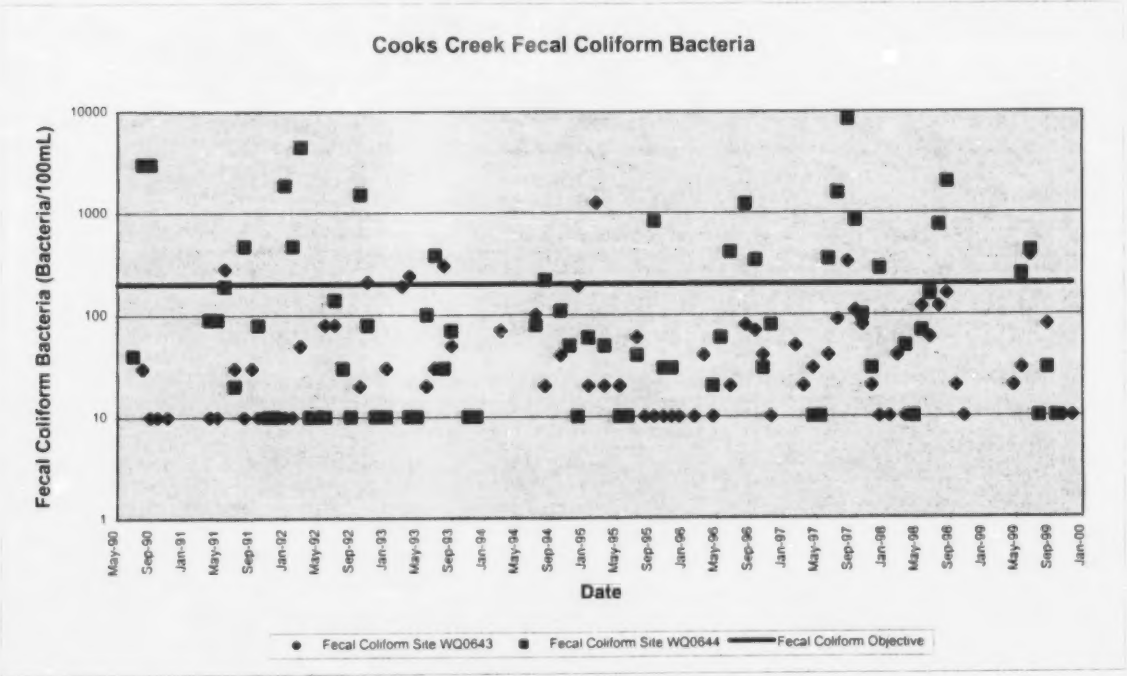

Figure 3. Cooks Creek fecal coliform bacteria at upstream site WQ0644 and downstream site WQ0643.

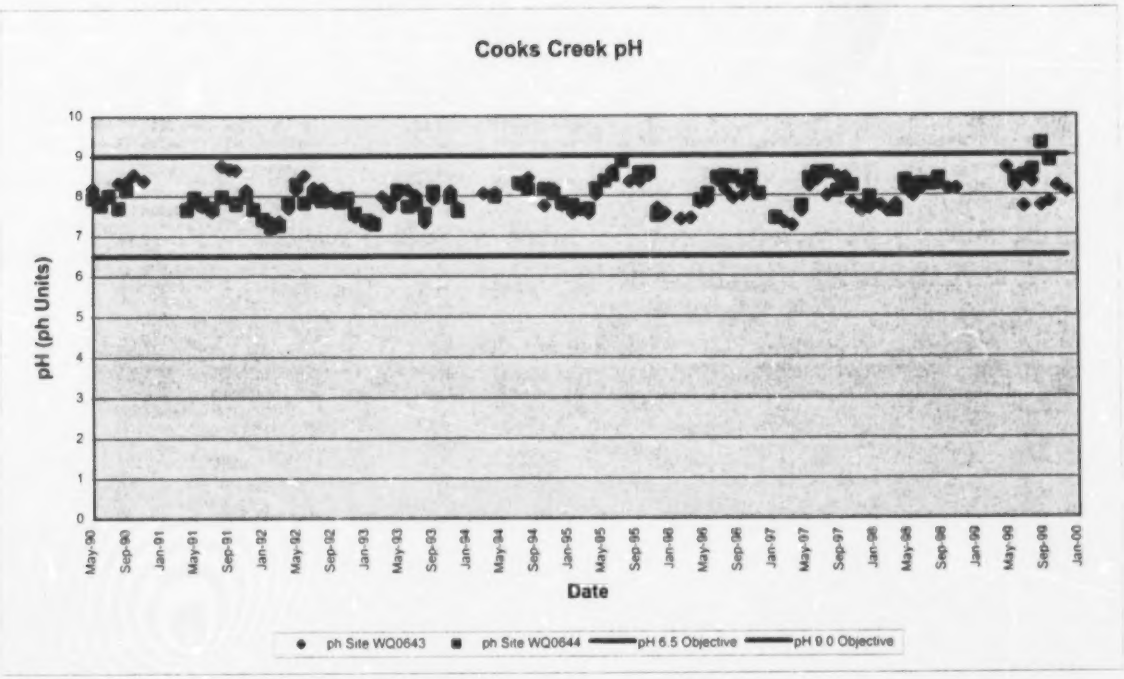

Figure 4. Cooks Creek pH at upstream site WQ0644 and downstream site WQ0643.

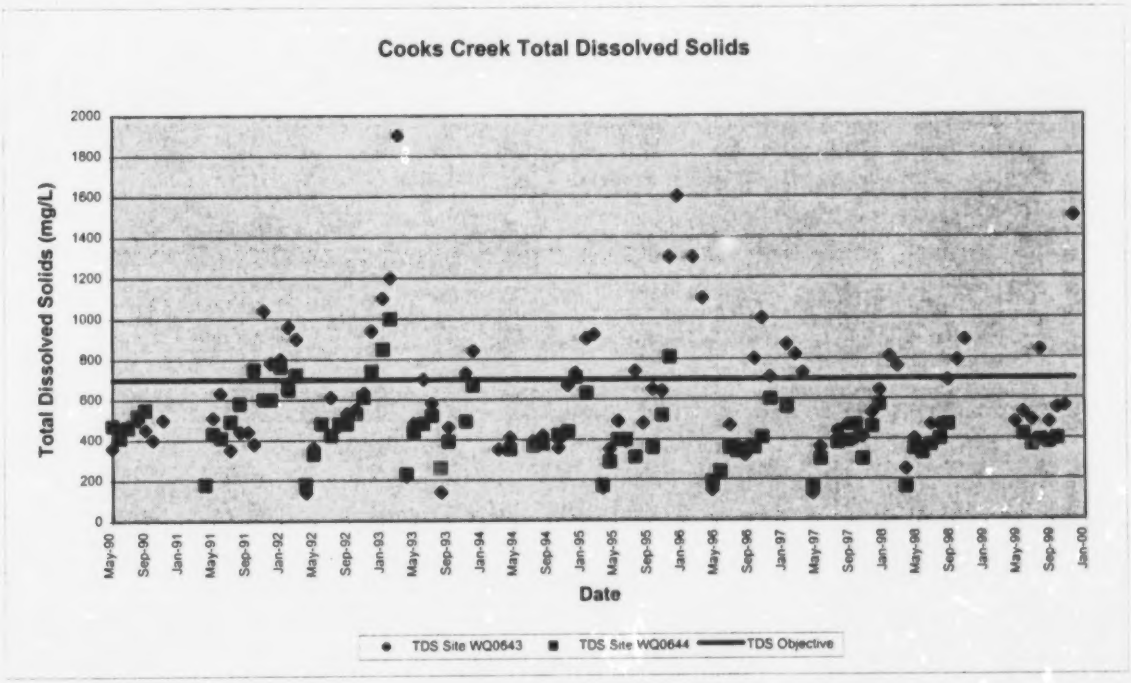

Figure 5. Cooks Creek dissolved solids at upstream site WQ0644 and downstream site WQ0643.

Dissolved Minerals

Total dissolved solids (TDS) include all dissolved material in water but mainly reflect the dissolved mineral content. Dissolved minerals include sodium, chloride, magnesium, potassium, and other elements. Within 97 samples collected from Site WQ0643, 33% of the TDS exceeded 700 mg/L, an objective for the protection of greenhouse irrigation (Appendix 1 and Figure 5). The objective for conductivity for the protection of greenhouse irrigation is 1000 µS/cm (approximately 700 mg/L of TDS) an objective used in calculation of the CWQI (Table 1). The 1000 µS/cm objective was exceeded 35% of the time in 98 samples at downstream site WQ0643 (Appendix 1 and Figure 6). Excursions from these guidelines were less frequent at upstream site WQ0644 with TDS of 700 mg/L exceeded in 10% of 78 samples and specific conductivity of 1000 µS/cm exceeded in 13% of 79 samples (Figures 5 and 6). The drinking water aesthetic objectives of 500 mg/L for TDS and 700 µS/cm for conductivity were exceeded considerably more frequently at both sites (Figures 5 and 6). However, the objective for livestock use is 3000 mg/L for TDS and 4300 µS/cm for conductivity; these objectives were never approached.

Of the major constituents of TDS, only chloride tended to exceed objectives at the downstream site WQ0643. Chloride tended to exceed the greenhouse irrigation objective of 100 mg/L occasionally during most years and more frequently from 1994 through 1996 (Appendix 1). Other chloride objectives were exceeded less frequently and mainly in the winter.

Both TDS and specific conductivity increased significantly from the upstream site to the downstream site (Figures 5 and 6). Some of this would have been due to natural phenomena such as intrusion of saline groundwater but some TDS could be contributed by treated sewage discharges. There may also be some input from uncapped flowing wells (Hughes *et al.* 1994). Also, diversion of a portion of water during high flow periods by the Cooks Creek Diversion channel would reduce the potential for dilution at the downstream site. Ground water in the area is treated with water softeners that add salts to the effluent. Since the source of the domestic water in Oakbank is ground water, increased dissolved solids at the downstream site WQ0643 may in part be due to impact from the treated effluent from Oakbank which enters Cooks Creek via Swede Drain.

Suspended Sediment

Suspended sediment tends to increase with higher stream velocity due to scouring of banks and stream beds. Suspended sediment can also be added to streams from local lands due to events such as rainstorms. This sediment can carry pollutants such as phosphorus, nitrogen, or agricultural pesticides. Sediment may also settle out in slower moving reaches or pools, possibly on fish spawning beds.

The objective used for total suspended solids or sediment (TSS) is 25 mg/L for the protection of aquatic life (Williamson 1988). At the downstream site WQ0643, this objective was exceeded in 7% of 97 samples WQ0643 (Appendix 1 and Figure 7). At the upstream site WQ0644, the TSS objective was exceeded in 32% of 77 samples.

Both the TSS and the related turbidity were significantly higher at the upstream site WQ0644 (Figures 7 and 8). Since the upstream site is located in a shallow excavated channel, there would tend to be more scouring occur than at the downstream site WQ0643 where the water is relatively deep in a natural meandering channel. Also, since some of the water is diverted down the Cooks Creek Diversion during high flow periods there would also tend to be less scouring in the lower reaches of the stream.

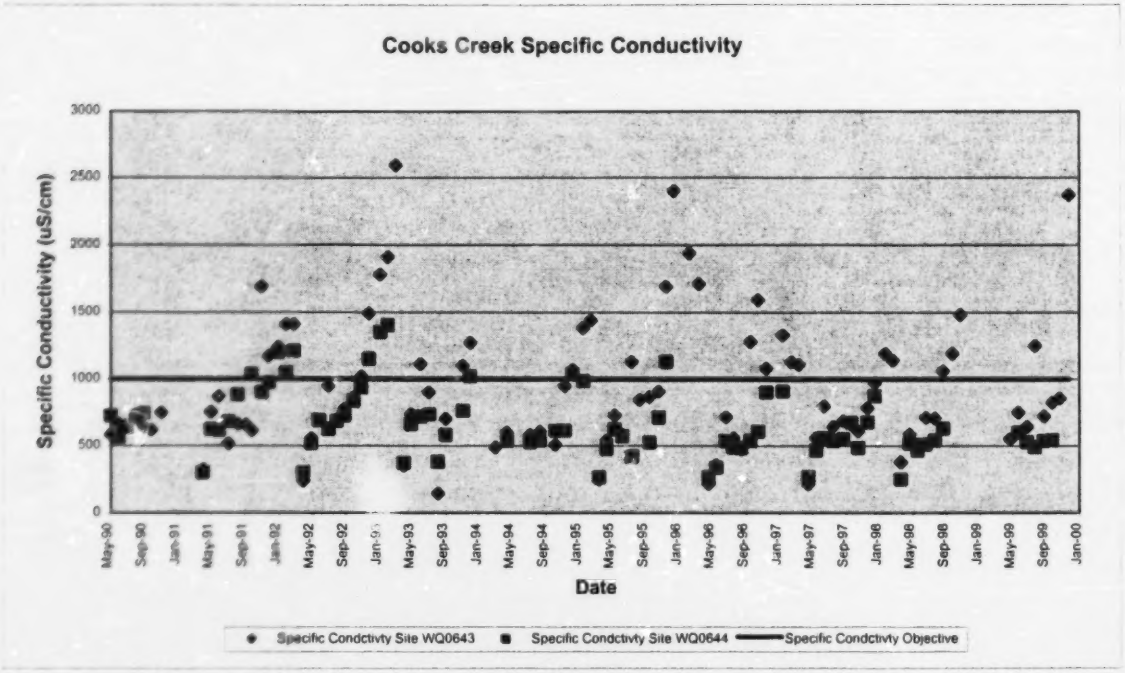

Figure 6. Cooks Creek specific conductivity at upstream site WQ0644 and downstream site WQ0643.

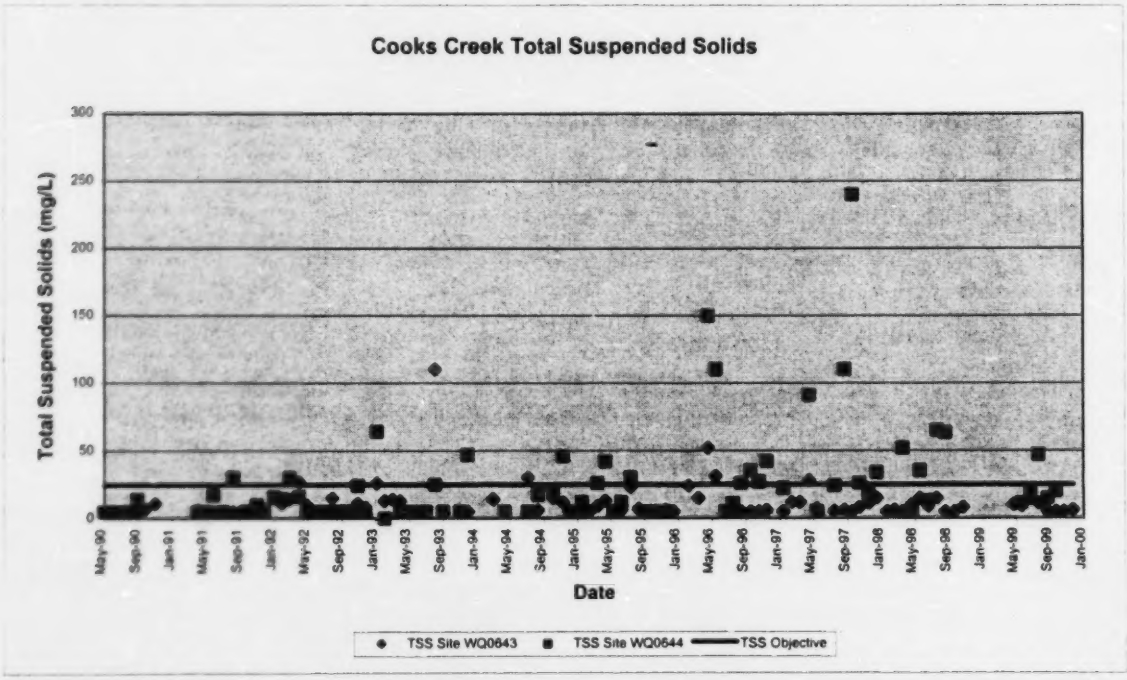

Figure 7. Cooks Creek suspended solids at upstream site WQ0644 and downstream site WQ0643.

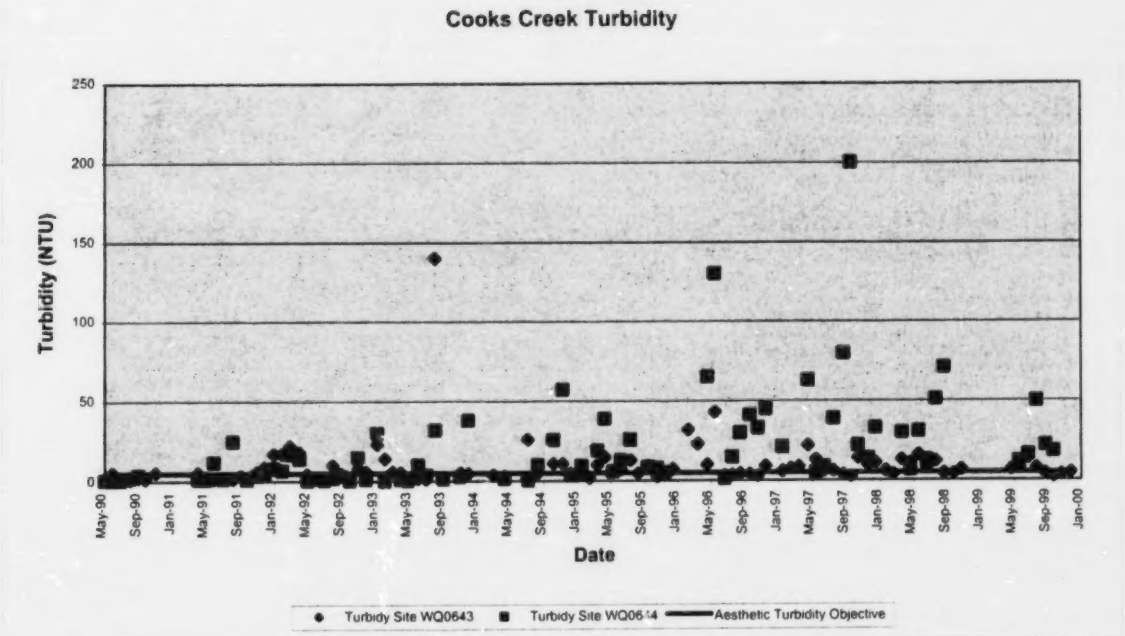

Figure 8. Cooks Creek turbidity at upstream site WQ0644 and downstream site WQ0643.

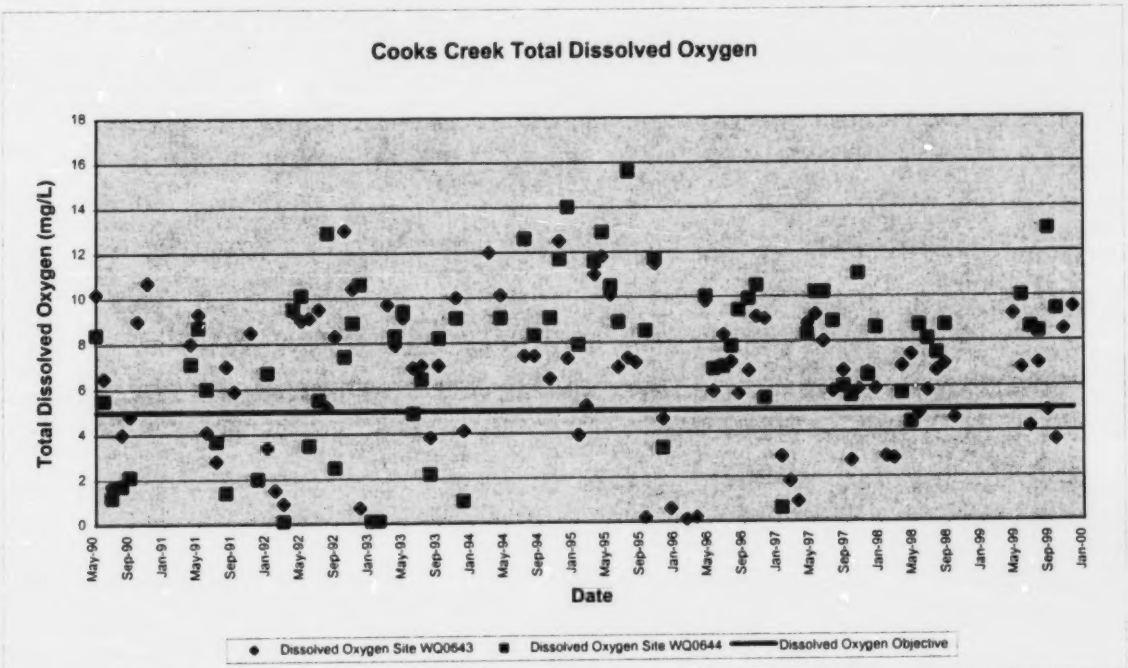

Figure 9. Cooks Creek dissolved oxygen at upstream site WQ0644 and downstream site WQ0643.

Dissolved Oxygen

Concentrations of dissolved oxygen should be above 5 mg/L throughout most of the year in order to maintain a healthy aquatic life community. Some fish species will not be present where dissolved oxygen levels fall below 3.0 mg/L. Fish kills are likely to occur with oxygen levels of 1.0 mg/L or less.

At downstream site WQ0643 dissolved oxygen was less than 5 mg/L in 40% of 95 samples while at upstream site WQ0644 dissolved oxygen was less than 5 mg/L in 43% of 76 samples (Figure 9). The majority of low dissolved oxygen values occurred during the winter and there were three values of less than 1.0 mg/L at each site. There was no significant difference in dissolved oxygen between the two sites. Fish kills are likely to occur at both locations due to low oxygen during some winters and, in the case of the upstream site, it is also likely to freeze to the bottom.

Phosphorus

Plant nutrients include phosphorus and nitrogen. Sources of plant nutrients include agricultural lands, treated domestic and industrial wastes, animal wastes, and natural sources. Phosphorus is the plant nutrient that is most frequently in limited supply in surface waters. Increased phosphorus concentrations in rivers and lakes can lead to increased abundance of algae and macrophytes (rooted aquatic plants).

Total phosphorus exceeded the recommended objective of 0.05 mg/L (Williamson 1988) in all 98 samples from the downstream site WQ0643 and 59% of 79 samples at the upstream site WQ0644 (Appendix 1, Figure 10). Manitoba Conservation's nutrient strategy involves a review of nutrient data for Manitoba and new site-specific objectives for phosphorus are likely to be established in the future. The phosphorus concentration was significantly greater at the downstream site. There are probably two main reasons for the additional phosphorus at the downstream site. Firstly, due to the location of the Cooks Creek Diversion channel between the sites some potential flushing at the downstream site may not occur during some periods of high flow when a portion of Cooks Creek water is diverted directly to the Red River. The findings of a previous study indicated that there was a significant correlation with flow rates (discharge), indicating dilution of total phosphorus at higher discharge rates at upstream site WQ0644 (Hughes *et al.* 1994). It is likely that this relationship still applies. Also the same study indicated that no relationship was found between total phosphorus and discharge at the downstream site WQ0643 or between total phosphorus and precipitation at either site. Secondly, the downstream site receives some extra contributions of phosphorus from effluent discharged from the Oakbank sewage lagoon as well as additional contributions of phosphorus from local agricultural lands.

Nitrogen

Nitrogen is an essential plant nutrient that tends to be abundant in surface waters. Nitrogen may be a limiting factor in plant growth in some Manitoba waters. Therefore like phosphorus, increased concentrations of nitrogen may lead to increased growth of aquatic plants. Some forms of nitrogen may be more readily available to certain plant species than to others. Nitrogen sources include treated sewage, livestock wastes, and runoff from agricultural lands. Total nitrogen includes three major forms of nitrogen: total ammonia (ammonium and gaseous un-ionized ammonia), nitrate-nitrite nitrogen, and organic nitrogen. Of these nitrogen compounds, nitrate-nitrite nitrogen and ammonia can cause problems which are not associated with plant growth.

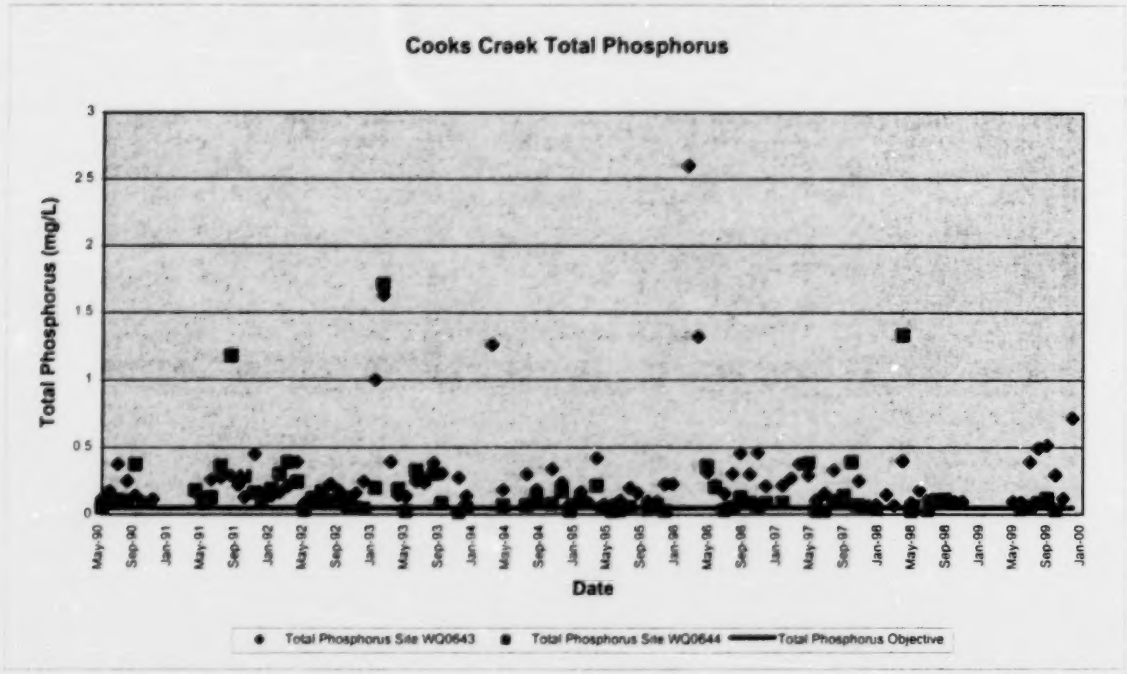

Figure 10. Cooks Creek total phosphorus at upstream site WQ0644 and downstream site WQ0643.

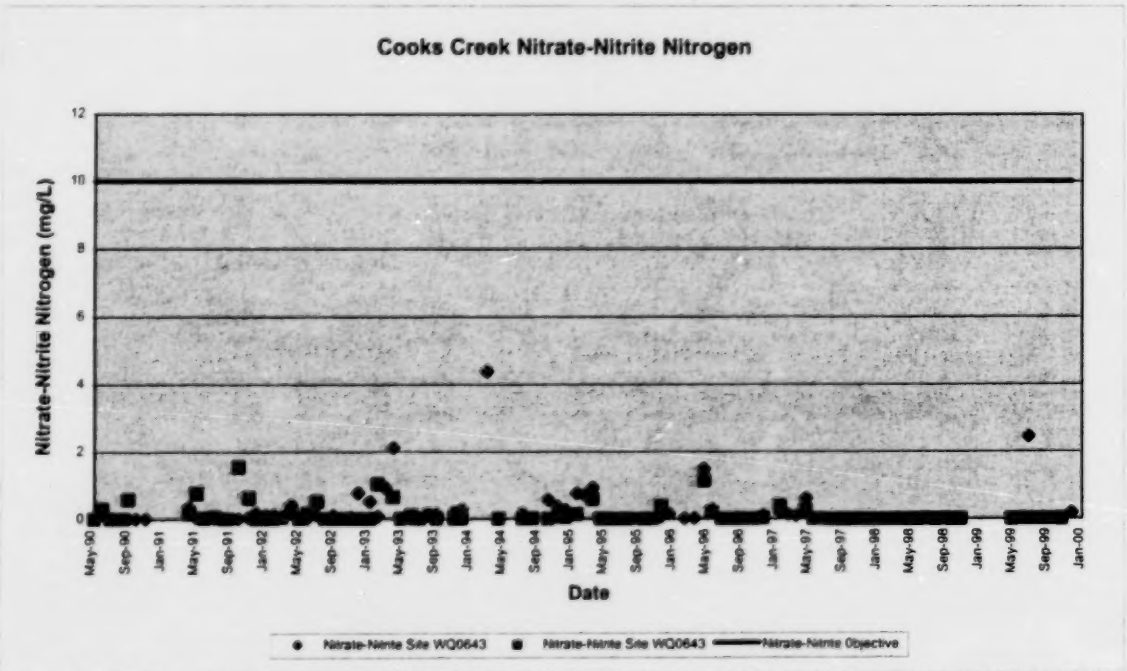

Figure 11. Cooks Creek nitrate-nitrite at upstream site WQ0644 and downstream site WQ0643.

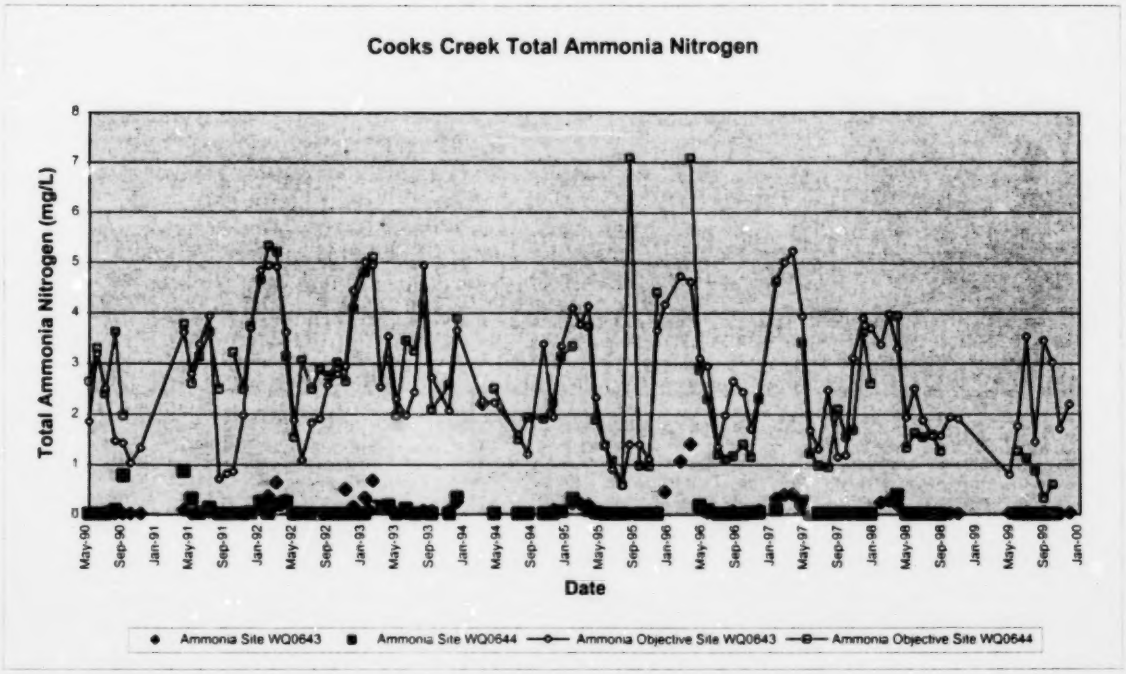

Figure 12. Cooks Creek total ammonia at upstream site WQ0644 and downstream site WQ0643.

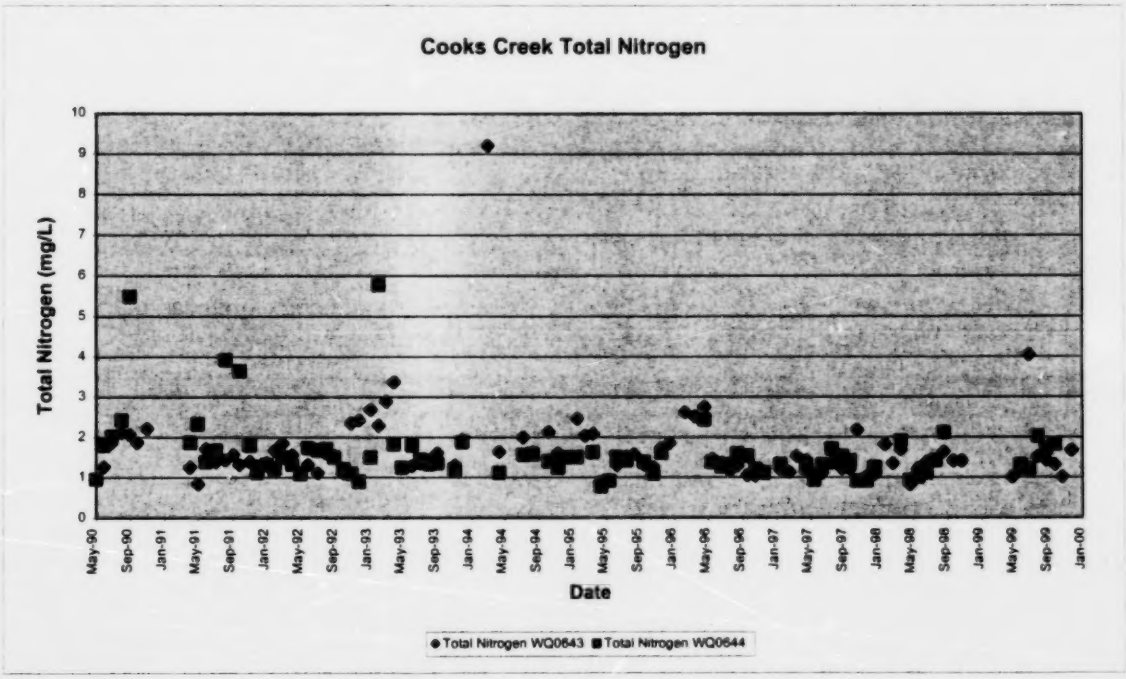

Figure 13. Cooks Creek total nitrogen at upstream site WQ0644 and downstream site WQ0643.

Nitrate-nitrite nitrogen peaked at downstream site WQ0643 on March 7, 1994 (Figure 11). Nitrate-nitrite nitrogen never approached the objective of 10 mg/L (Williamson 2001). There were no significant differences in paired data between upstream and downstream sites.

Ammonia, particularly the un-ionized portion, can be toxic to aquatic life. Total ammonia approached but did not exceed the objective for the protection of aquatic life (Williamson 2001) at downstream site WQ0643 on March 7, 1994 (Figure 12). None of the 79 samples collected from upstream site WQ0644 showed ammonia concentrations exceeding either objective although samples were not collected from this site in March of 1994. There were no significant differences in paired data between upstream and downstream sites.

Total nitrogen is the sum of total Kjeldahl nitrogen (which comprises organic nitrogen and total ammonia) and nitrate-nitrogen. The highest total nitrogen occurred at site WQ0643 on March 7, 1994 (Figure 13). There were no significant differences in paired data between upstream and downstream sites.

Trace Elements

Trace elements were measured in approximately 90 water samples collected at downstream site WQ0643. The objective for dissolved aluminum for the protection of aquatic life of 0.1 mg/L (where pH values are greater than 6.5) (Williamson 2001) was used in the CWQI. Only 14 samples were analyzed for dissolved aluminum; none of the dissolved aluminum results exceeded this objective (Table 1 and Appendix 1). Proposed objectives for the protection of aquatic life are for the dissolved portion of cadmium, copper, nickel, lead, zinc, and hexavalent chromium (Williamson 2001). All of these metals were measured either in extractable or total concentrations but not in dissolved concentrations. In any case excursions from objectives were minimal. Hexavalent chromium was never detected, no excursions occurred for cadmium or nickel, one excursion occurred for lead, two excursions occurred for copper (Table2). Total arsenic was consistently below the objective of 0.025 required for drinking water.

Iron and manganese exceeded their respective lowest objectives on 35% and 37%, respectively, in 97 water samples collected at downstream site WQ0643 (Appendix 1). The iron objective in this case was 0.3 mg/L that is required for the protection of aquatic life. This is also an objective for aesthetic drinking water quality (Williamson 2001). The lowest manganese objective of 0.05 mg/L is established to ensure aesthetically pleasing drinking water. The manganese objective for irrigation of 0.2 mg/L was exceeded 16% of the time. The aesthetic drinking water guidelines for these two metals are not as significant as objectives for protection of aquatic life or irrigation since these metals can be removed in the drinking water treatment process.

Pesticides

Pesticides were measured in approximately 90 water samples collected from downstream site WQ0643. Many of the pesticides tested for were not detected (Appendix 1). The lowest objective for dicamba is for irrigation and is set at 0.006 µg/L (Williamson 2001) and this low-level requirement was exceeded on 15 occasions and may have done so on more occasions since the detection limits currently used are higher than the objective. Dicamba did not exceed any other objectives. The MCPA objective for the protection of irrigation water is 0.025 µg/L and this was exceeded on four occasions when detected. The objective for the protection of aquatic life for MCPA is 2.6 µg/L. This was exceeded on only three occasions when detected at levels of 11, 15 and 27 µg/L in 1993 and 1994. Although this was not the case in the past, the current

detection level for MCPA is below the aquatic life objective. As previously noted, since the excursions or magnitude of exceedences for MCPA at the lower level objective were extreme, the 2.6 µg/L objective was used in calculating the CWQI water quality indices (CCME 2000). Of the other pesticides used in calculations of the CWQI, 2,4-D, simazine, and bromoxynil only exceeded their lowest objectives on one occasion each, and lindane, atrazine, and trifluralin never exceeded their objectives.

OVERVIEW

Water quality in Cooks Creek is generally acceptable for most purposes.

- The water quality index for the downstream site located at the boundary of the Rural municipalities of Springfield and St. Clements indicates water quality is in the fair range but, in some years, it occasionally approaches good water quality.

- As with other areas where drinking water may be drawn from rivers or lakes, some water treatment is required prior to consumption.

- Fecal coliform bacteria only exceeded the objective of 200 fecal colifrom bacteria/100 mL for recreational water quality in 7% of the samples at the downstream site at the boundary of the rural municipalities of Springfield and St. Clements. Also, at this site annual average fecal coliform counts were acceptable. However, at the upstream site, fecal coliform counts were significantly greater. The fecal coliform counts exceeded this objective in 31% of the samples at the upstream site near Millbrook and it appears that the source of these bacteria may be largely due to livestock housed in the floodplain and cattle being allowed to drink directly from the stream.

- Total dissolved solids and specific conductivity were significantly higher at the downstream site than at the upstream site. This may be due in part to a reduction in dilution potential when a portion of water is diverted down the Cooks Creek Diversion during periods of high flow but also due in part to additional sources such as effluent from Oakbank or uncapped flowing wells. The total dissolved solids and specific conductivity exceeded greenhouse irrigation objectives in approximately 38% of the samples at the downstream site and 10% of the samples at the upstream site.

- Total suspended solids (sediment) were significantly higher at the upstream site probably mainly due to reduced scouring at the downstream site. The upstream site is located in a shallow channelized reach and would be more susceptible to scouring. Also, a portion of water is diverted down the Cooks Creek Diversion during periods of high flow that would also reduce the impact of scouring at the downstream site. Total suspended solids exceeded the objective of 25 mg/L 32% of the time at the upstream site and 7% of the time at the downstream site.

- Total phosphorus was present in sufficient concentrations to readily stimulate plant growth, typical of many southern Manitoba lakes and streams. Total phosphorus was significantly higher at the downstream site probably due in part to addition of effluent from Oakbank but also in part due to a reduction in dilution potential when a portion of water is diverted down the Cooks Creek Diversion during periods of high flow.

- Dissolved oxygen concentrations were below a desirable concentration approximately 40% of the time or more at both sites. Winter dissolved oxygen concentrations were occasionally low enough to potentially cause stress and fish kills.

- Iron and manganese were higher than drinking water objectives in 35% or more of the samples. These levels are probably natural and can be removed during drinking water treatment processes.

- Pesticides were frequently less than detection limits with only a few pesticides exceeding their respective objectives. However, during 1993 and 1994 MCPA was detected on three occasions at relatively high concentrations.

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Appendix 1. Annual water quality averages, ranges, and objective exceedances at Cooks Creek site WQ0643.

Appendix 1. Annual water quality averages, ranges, and objective exceedances at Cooks Creek site WQ0643.

Statistic	Date	Bactena Fecal Coliform	Temperatur	pH	Specific Conductivity	Solids Total Dissolved	Solids Total Suspended	Turbidity	True Colour
Units		Bactena/100 m	°C	pH units	uS/cm	mg/L	mg/L	NTU	Colour Units
Average	1990	< 16	15 5	8 22	660	447	< 6	2 60	> 50
High	1990	40	26 0	8 53	749	500	11	5 50	> 50
Low	1990	< 10	8 0	7 80	582	360	< 5	0 71	> 50
N Samples	1990	5	7	7	7	7	7	7	7
Objectives	1990	Not		D=1	D, GI=0	D, GI=0	Not	R=0, D=2	D=7
Exceeded		Exceeded		A R=0	FI, L=0	FI, L=0	Exceeded		
Average	1991	< 18	11 0	8 09	806	528	5	3 60	> 50
High	1991	280	21 0	8 75	1690	1040	7	8 80	> 50
Low	1991	< 10	0 0	7 61	322	180	< 5	1 48	50
N Samples	1991	9	9	9	9	9	9	9	9
Objectives	1991	R=1		D=3	D=4, GI=2,	D=4, GI=2,	Not	R=0, D=3	D=9
Exceeded				A,R=0	FI,L=0	FI,L=0	Exceeded		
Average	1992	< 24	8 0	7 83	944	614	< 11	9 33	> 47
High	1992	210	20 0	8 50	1490	960	27	22 00	> 50
Low	1992	< 10	0 0	7 34	240	140	< 5	1 60	25
N Samples	1992	11	12	12	12	12	12	12	12
Objectives	1992	R=1		D,A,R=0	D=7, GI=4,	D=7, GI=4,	A=1	R=0, D=5	D=12
Exceeded					FI,L=0	FI,L=0			
Average	1993	< 36	7.0	7 81	1111	732	< 19	17 61	> 48
High	1993	> 300	18 0	8 14	2590	1900	110	140 00	> 50
Low	1993	< 10	0 0	7 32	144	140	< 5	1 20	35
N Samples	1993	11	12	12	12	12	12	12	12
Objectives	1993	R=2		D,A,R=0	D=7, GI=4,	D=7, GI=4,	A=2	R=1, D=7	D=12
Exceeded					FI=3, L=0	FI=3, L=0			
Average	1994	61	9 0	8 07	685	476	< 12	9 24	> 50
High	1994	190	22 0	8 44	1070	730	30	26 00	> 50
Low	1994	20	0 0	7 75	487	350	< 5	3 00	50
N Samples	1994	6	7	7	7	7	7	7	7
Objectives	1994	Not		D,A,R=0	D=2, GI=1	D=2, GI=1	A=1	R=0, D=4	D=7
Exceeded		Exceeded			FI,L=0	FI,L=0			
Average	1995	< 22	8 9	8 09	1063	718	< 8	7 30	> 40
High	1995	1240	24 0	8 88	2400	1600	23	15 00	> 50
Low	1995	< 10	0 0	7 55	250	160	< 5	1 80	20
N Samples	1995	11	12	12	12	12	12	12	12
Objectives	1995	R=1		D=1	D=7, GI=5	D=7, GI=5	Not	R=0, D=7	D=12
Exceeded				A,R=0	FI=2, L=0	FI=2, L=0	Exceeded		
Average	1996	< 26	8 3	7 92	992	646	< 15	13 56	> 48
High	1996	80	22 0	8 37	1940	1300	52	43 00	> 50
Low	1996	< 10	0 0	7 40	216	150	< 5	3 00	25
N Samples	1996	9	9	10	10	10	10	10	10
Objectives	1996	Not		D,A,R=0	D=5, GI=5	D=5, GI=5	A=2	R=0, D=6	D=10
Exceeded		Exceeded			FI=3, L=0	FI=3, L=0			
Average	1997	< 41	8 8	7 85	792	527	<10	9 28	> 36
High	1997	330	25 0	8 47	1330	870	28	22 00	60
Low	1997	< 10	0 0	7 25	215	130	< 5	2 50	< 5
N Samples	1997	11	12	12	12	11	11	12	12
Objectives	1997	R=1		D,A,R=0	D=5, GI=3	D=5, GI=3	A=1	R=0, D=10	D=10
Exceeded					FI,L=0	FI,L=0			
Average	1998	< 32	11 8	8 03	896	588	< 8	8 59	56
High	1998	160	24 0	8 28	1480	890	15	16 00	120
Low	1998	< 10	0 0	7 60	378	250	< 5	4 00	10
N Samples	1998	10	10	10	10	10	10	10	10
Objectives	1998	Not		D,A,R=0	D=5, GI=4	D=5, GI=4	A=0	R=0, D=7	D=8
Exceeded		Exceeded			FI,L=0	FI,L=0			
Average	1999	< 26	15.1	8.10	995	670	< 8	6 45	59
High	1999	380	26.0	8 68	2370	1500	14	14 00	100
Low	1999	< 10	0 0	7.71	550	480	< 5	2 20	30
N Samples	1999	8	8	8	8	8	8	8	8
Objectives	1999	R=1		D=1	D=5,GI=2	D=5,GI=2	Not	R=0, D=7	D=8
Exceeded				A,R=0	FI=1, L=0	FI=1, L=0	Exceeded		
Objectives									
Public Health								5 Aesthetic	
Drinking Water (D)		Treat to 0		Treat to 6.5 -8.5	700 Aesthetic	500 Aesthetic		or 1 Treated	15 Aesthetic
Recreation (R)		200		5.0-9.0					
Aquatic Life (A)				6.5-9.0			25		
Irrigation (I)									
Greenhouse (GI)					1000*	700*			
Field Crop (FI)					1500*	1000*			
Livestock (L)					4300	3000			
Promotes Nuisance Plants (P)									

Used for CWQI
Canadian Water Quality Index

* Most higher conductivities and higher total dissolved solids occcurred during the winter when no irrigation would occur

Appendix 1. Cont'd.

Statistic	Date	Alkalinity Total	Alkalinity Bicarbonate	Nitrogen Total Ammonia	Nitrogen Unionized Ammonia	Nitrogen Nitrate-Nitrite	Nitrogen Total Kjeldahl	Phosphorus Total	Phosphorus Total Particulate
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Average	1990	283	332	0.023	0.00138	0.03	1.73	0.180	
High	1990	340	412	0.035	0.00234	0.16	2.20	0.375	
Low	1990	209	255	0.020	0.00044	0.01	0.95	0.093	
N Samples	1990	7	7	7	7	7	7	7	
Objectives Exceeded	1990			Not Exceeded	Not Exceeded	Not Exceeded		P=7	
Average	1991	274	317	0.037	0.00148	0.08	1.27	0.225	
High	1991	397	484	0.095	0.00443	0.35	1.70	0.450	
Low	1991	96	117	0.020	0.00019	0.01	0.80	0.080	
N Samples	1991	9	9	9	9	9	9	9	
Objectives Exceeded	1991			Not Exceeded	Not Exceeded	Not Exceeded		P=9	
Average	1992	352	427	0.187	0.00133	0.15	1.43	0.177	
High	1992	533	651	0.640	0.00437	0.77	2.29	0.390	
Low	1992	98	120	0.020	0.u0037	0.01	1.00	0.083	
N Samples	1992	12	12	12	12	12	12	12	
Objectives Exceeded	1992			Not Exceeded	Not Exceeded	Not Exceeded		P=12	
Average	1993	372	454	0.160	0.00105	0.39	1.51	0.419	
High	1993	636	776	0.677	0.00197	2.11	2.21	1.630	
Low	1993	54	66	0.020	0.00036	0.01	1.08	0.134	
N Samples	1993	12	12	12	12	12	12	12	
Objectives Exceeded	1993			Not Exceeded	Not Exceeded	Not Exceeded		P=12	
Average	1994	251	301	0.354	0.00495	0.82	1.99	0.367	
High	1994	515	628	2.200	0.02452	4.38	4.82	1.260	
Low	1994	121	148	0.020	0.00036	0.01	1.24	0.074	
N Samples	1994	7	7	7	7	7	7	7	
Objectives Exceeded	1994			Not Exceeded	A=1	Not Exceeded		P=7	
Average	1995	358	419	0.107	0.00178	0.22	1.34	0.161	
High	1995	667	814	0.458	0.00661	0.82	1.70	0.419	
Low	1995	88	107	0.020	0.00020	0.01	0.80	0.070	
N Samples	1995	12	12	12	12	12	12	12	
Objectives Exceeded	1995			Not Exceeded	Not Exceeded	Not Exceeded		P=12	
Average	1996	314	381	0.295	0.00184	0.20	1.44	0.633	0.149
High	1996	597	729	1.410	0.00396	1.48	2.60	2.600	0.740
Low	1996	76	92	0.020	0.00056	0.01	1.03	0.156	0.023
N Samples	1996	10	10	10	9	10	10	10	7
Objectives Exceeded	1996			Not Exceeded	Not Exceeded	Not Exceeded		P=10	
Average	1997	334	400	0.121	0.00110	0.18	1.11	0.193	0.043
High	1997	530	646	0.410	0.00328	0.77	1.44	0.374	0.174
Low	1997	85	104	0.020	0.00008	0.01	0.82	0.063	0.011
N Samples	1997	12	12	12	12	12	12	12	12
Objectives Exceeded	1997			Not Exceeded	Not Exceeded	Not Exceeded		P=12	
Average	1998	330	403	0.085	0.00106	0.15	1.26	0.137	0.031
High	1998	536	654	0.280	0.00139	0.51	1.60	0.398	0.087
Low	1998	149	181	0.010	0.00042	0.01	0.80	0.067	0.011
N Samples	1998	10	10	10	10	10	10	10	10
Objectives Exceeded	1998			Not Exceeded	Not Exceeded	Not Exceeded		P=10	
Average	1999	288	344	0.023	0.00122	0.34	1.31	0.339	0.027
High	1999	455	556	0.040	0.00481	2.44	1.60	0.716	0.039
Low	1999	166	203	0.010	0.00018	0.01	1.00	0.090	0.012
N Samples	1999	8	8	8	8	8	8	8	8
Objectives Exceeded	1999			Not Exceeded	Not Exceeded	Not Exceeded		P=8	
Objectives									
Public Health									
Drinking Water (D)		Unlisted	Unlisted			10	Unlisted		Unlisted
Recreation (R)									
Aquatic Life (A)				Calculated	Calculated				
Irrigation (I)									
Greenhouse (GI)									
Field Crop (FI)									
Livestock (L)									
Promotes Nuisance Plants (P)								0.05	

Used for CWQI

Canadian Water Quality Index

Appendix 1. Cont'd.

Statistic Units	Date	Phosphorus Total Dissolved mg/L	Carbon Total Organic mg/L	Carbon Total Inorganic mg/L	Oxygen Dissolved mg/L	Oxygen Saturation %	Chloride mg/L	Sulphate mg/L	Boron Total mg/L	Boron Dissolved mg/L
Average	1990		31.8	64.7	6.7	63%	29	45		0.15
High	1990		41.0	79.0	10.7	96%	43	80		0.23
Low	1990		13.0	49.0	1.7	21%	10	25		0.09
N Samples	1990		7	7	7	7	7	7		7
Objectives Exceeded	1990				A=3	A=2	Not Exceeded	Not Exceeded		Not Exceeded
Average	1991		15.2	67.2	6.5	59%	48	98		0.13
High	1991		20	100.0	9.3	77%	206	218		0.18
Low	1991		11.0	21.5	2.8	31%	12	30		0.07
N Samples	1991		9	9	7	7	9	9		9
Objectives Exceeded	1991				A=2	A=3	D=1 GI=1, FI=0	Not Exceeded		Not Exceeded
Average	1992		14	92.3	6.7	60%	40	134		0.14
High	1992		25	140.0	13.0	115%	96	261		0.21
Low	1992		5	25.0	0.7	5%	5	15		0.08
N Samples	1992		12	12	12	12	12	12		12
Objectives Exceeded	1992				A=4	A=4	Not Exceeded	Not Exceeded		Not Exceeded
Average	1993		19	89.9	6.3	53%	73	174		0.10
High	1993		32	166.0	10.0	83%	190	917		0.18
Low	1993		6	15.5	< 0.1	1%	5	12		< 0.05
N Samples	1993		12	12	12	12	12	12		12
Objectives Exceeded	1993				A=4	A=4	D=0 GI=3, FI=0	Not Exceeded		Not Exceeded
Average	1994		20	57.7	9.0	76%	25	97		0.10
High	1994		32	104.0	12.5	92%	34	270		0.14
Low	1994		9	29.5	6.4	50%	16	12		0.06
N Samples	1994		7	7	7	7	7	7		7
Objectives Exceeded	1994				Not Exceeded	Not Exceeded	Not Exceeded	Not Exceeded		Not Exceeded
Average	1995		16	86.5	6.7	59%	86	139		0.09
High	1995		36	170.0	11.8	100%	346	401		0.12
Low	1995		1	21.7	0.2	2%	10	12		0.05
N Samples	1995		12	12	12	12	12	12		9
Objectives Exceeded	1995				A=4	A=5	D=2 GI=4, FI=0	Not Exceeded		Not Exceeded
Average	1996	0.308	17	78.3	6.2	53%	89	113		
High	1996	0.580	25	156.0	9.8	88%	218	292		
Low	1996	0.131	10	18.4	< 0.1	1%	10	12		
N Samples	1996	7	10	10	10	9	10	10		
Objectives Exceeded	1996				A=2	A=2	D=0 GI=4, FI=0	Not Exceeded		
Average	1997	0.150	16	81.9	5.4	49%	26	86	< 0.05	< 0.06
High	1997	0.310	22	140.0	9.2	90%	53	257	0.06	0.07
Low	1997	0.050	4	21.3	0.9	6%	10	17	< 0.05	< 0.05
N Samples	1997	12	12	12	12	12	12	12	3	3
Objectives Exceeded	1997				A=4	A=6	Not Exceeded	Not Exceeded	Not Exceeded	Not Exceeded
Average	1998	0.106	17	79.7	5.4	53%	45	72	0.07	0.05
High	1998	0.359	25	132.0	7.4	83%	203	165	0.09	0.07
Low	1998	0.055	10	37.0	2.8	19%	10	12	< 0.05	< 0.05
N Samples	1998	10	10	10	9	9	8	8	8	6
Objectives Exceeded	1998				A=4	A=3	D=0 GI=1, FI=0	Not Exceeded	Not Exceeded	Not Exceeded
Average	1999	0.312	19	67.0	6.7	65%	90	148	0.08	
High	1999	0.679	25	100.0	9.5	95%	350	304	0.13	
Low	1999	0.065	15	39.0	3.6	33%	21	104	0.05	
N Samples	1999	8	8	8	8	8	8	8	3	
Objectives Exceeded	1999				A=3	A=2	D=1 GI=2, FI=0	Not Exceeded	Not Exceeded	
Objectives										
Public Health										
Drinking Water (D)		Unlisted	Unlisted	Unlisted			250 Aesthetic	500 Aesthetic	5.0	5.0
Recreation (R)										
Aquatic Life (A)					6	0.47%				
Irrigation (I)					Range 3-6	Cool Water				
Greenhouse (GI)							100*		0.5	0.5
Field Crop (FI)							700		1.0-6.0	1.0-6.0
Livestock (L)								1000	5.0	5.0
Promotes Nuisance Plants (P)										

Used for CWQI

Canadian Water Quality Index

* Most higher chloride occcurred during the winter when no irrigation would occur

Appendix 1. Cont'd.

Statistic	Date	Magnesium Total	Magnesium Extractable	Sodium Total	Sodium Extractable	Sodium Adsorption	Potassium Total	Potassium Extractable	Calcium Total	Calcium Extractable
Units		mg/L	mg/L	mg/L	mg/L	Ratio	mg/L	mg/L	mg/L	mg/L
Average	1990		43.7		26.6	0.7		6.51		53.9
High	1990		52.0		36.7	0.9		8.60		72.7
Low	1990		34.0		14.0	0.3		< 5.00		38.0
N Samples	1990		7		7	7		7		7
Objectives Exceeded	1990				Not Exceeded	Not Exceeded				
Average	1991		46.0		34.0	0.8		8.12		58.9
High	1991		74		131	2.5		11.70		91.6
Low	1991		17.5		9.70	0.30		6.00		27.0
N Samples	1991		9		9	9		9		9
Objectives Exceeded	1991				Not Exceeded	Not Exceeded				
Average	1992		60.7		35.1	0.7		6.57		79.8
High	1992		92.5		81.0	1.4		10.00		123.0
Low	1992		13.9		4.4	0.2		< 5.00		21.9
N Samples	1992		12		12	12		12		12
Objectives Exceeded	1992				Not Exceeded	Not Exceeded				
Average	1993		61.9		47.4	0.9		7.54		79.5
High	1993		117.0		122.0	1.9		13.30		135.0
Low	1993		10.3		3.1	0.2		5.10		12.2
N Samples	1993		11		11	11		12		11
Objectives Exceeded	1993				Not Exceeded	Not Exceeded				
Average	1994		45.9		20.4	0.5		8.27		59.4
High	1994		70.0		30.5	0.6		19.20		122.0
Low	1994		23.2		12.1	0.4		< 5.00		31.4
N Samples	1994		7		7	7		7		7
Objectives Exceeded	1994				Not Exceeded	Not Exceeded				
Average	1995		65.4		62.6	1.2		6.53		80.5
High	1995		132.0		235.0	3.5		11.30		150.0
Low	1995		15.6		6.5	0.3		4.11		18.6
N Samples	1995		12		12	12		12		12
Objectives Exceeded	1995				Not Exceeded	Not Exceeded				
Average	1996		54.7		67.2	1.3		7.35		71.6
High	1996		114.0		162.0	3.0		10.90		119.0
Low	1996		12.4		5.3	0.2		2.99		18.2
N Samples	1996		10		10	10		10		10
Objectives Exceeded	1996				Not Exceeded	Not Exceeded				
Average	1997	47.7	52.5	18.5	24.6	0.5	5.37	5.31	77.4	75.3
High	1997	60.1	88.3	21.3	44.4	0.9	6.80	6.84	103.0	113.0
Low	1997	36.9	12.6	15.5	4.2	0.2	4.60	3.60	49.6	20.6
N Samples	1997	3	12	3	12	12	3	12	3	12
Objectives Exceeded	1997			Not Exceeded	Not Exceeded	Not Exceeded				
Average	1998	50.8	48.4	36.6	18.7	0.7	4.66	4.45	77.4	79.0
High	1998	78.3	81.7	148.0	36.3	2.8	6.62	5.70	123.0	127.0
Low	1998	21.2	21.1	7.0	6.8	0.2	2.80	2.90	30.7	31.6
N Samples	1998	8	6	8	6	8	8	6	8	6
Objectives Exceeded	1998			Not Exceeded	Not Exceeded	Not Exceeded				
Average	1999	60.4		71.3		1.4	8.23		88.9	
High	1999	114.0		253.0		4.2	11.30		94.1	
Low	1999	37.0		23.0		0.5	5.97		44.2	
N Samples	1999	8		8		8	8		8	
Objectives Exceeded	1999			D=1		GI=1				
Objectives										
Public Health										
Drinking Water (D)		Unlisted	Unlisted	200 Aesthetic	200 Aesthetic		Unlisted	Unlisted	Unlisted	Unlisted
Recreation (R)										
Aquatic Life (A)										
Irrigation (I)										
Greenhouse (GI)						4.0*				
Field Crop (FI)						6.0				
Livestock (L)										
Promotes Nuisance Plants (P)										

Used for CWQI

Canadian Water Quality Index

* One winter Exceedance

Appendix 1. Cont'd.

Statistic	Date	Hardness Total	Aluminum Dissolved	Aluminum Total	Aluminum Extractable	Arsenic Total	Cadmium Total	Cadmium Extractable	Copper Total
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Average	1990	315			0 141	0 005		< 0 0010	
High	1990	374			0 434	0 008		< 0 0010	
Low	1990	272			0 016	0 003		< 0 0010	
N Samples	1990	7			6	7		7	
Objectives	1990	D=7			A=2	Not		Not	
Exceeded					I,L=0	Exceeded		Exceeded	
Average	1991	336			0 154	0 004		< 0 0010	
High	1991	525			0 386	0 007		< 0 0010	
Low	1991	140			< 0 010	0 001		< 0 0010	
N Samples	1991	9			9	9		9	
Objectives	1991	D=8			A=5	Not		Not	
Exceeded					I,L=0	Exceeded		Exceeded	
Average	1992	449			0 197	0 002		< 0 0010	
High	1992	688			0 742	0 003		< 0 0010	
Low	1992	112			0 018	0 001		< 0 0010	
N Samples	1992	12			12	12		12	
Objectives	1992	D=11			A=6	Not		Not	
Exceeded					I,L=0	Exceeded		Exceeded	
Average	1993	454			0 560	0 003		< 0 0010	
High	1993	819			3 900	0 004		< 0 0010	
Low	1993	73			< 0 010	0 001		< 0 0010	
N Samples	1993	11			12	12		12	
Objectives	1993	D=9			A=5	Not		Not	
Exceeded					I,L=0	Exceeded		Exceeded	
Average	1994	337			0 158	0 003		< 0 0010	
High	1994	592			0 262	0 005		< 0 0010	
Low	1994	174			< 0 010	0 001		< 0 0010	
N Samples	1994	7			7	7		7	
Objectives	1994	D=6			A=5	Not		Not	
Exceeded					I,L=0	Exceeded		Exceeded	
Average	1995	470			0 309	0 003		< 0 0010	
High	1995	875			0 917	0 008		< 0 0010	
Low	1995	111			< 0 010	0 001		< 0 0010	
N Samples	1995	12			12	12		12	
Objectives	1995	D=11			A=9	Not		Not	
Exceeded					I,L=0	Exceeded		Exceeded	
Average	1996	404			0 429	0 004		< 0 0010	
High	1996	766			1 130	0 007		< 0 0010	
Low	1996	97			0 081	0 002		< 0 0005	
N Samples	1996	10			10	10	–	10	
Objectives	1996	D=9			A=9	Not		Not	
Exceeded					I,L=0	Exceeded		Exceeded	
Average	1997	404	0 017	1 107	0 288	0 003	< 0 0005	< 0 0005	0 009
High	1997	646	0 030	1 400	0 508	0 008	0 0005	0 0007	0 010
Low	1997	103	0 010	0 720	0 135	0 001	< 0 0005	< 0 0005	0 008
N Samples	1997	12	3	3	12	12	3	12	3
Objectives	1997	D=11	Not	A=3	A=12	Not	Not	Not	Not
Exceeded			Exceeded	I,L=0	I,L=0	Exceeded	Exceeded	Exceeded	Exceeded
Average	1998	412	0 015	0 722	0 307	0 002	< 0 0004	< 0 0005	< 0 004
High	1998	653	0 020	1 400	0 700	0 004	< 0 0005	< 0 0005	0 007
Low	1998	166	0 010	0 440	0 080	< 0 001	< 0 0002	< 0 0005	< 0 001
N Samples	1998	8	8	5	6	8	8	6	8
Objectives	1998	D=7	Not	A=5	A=5	Not	Not	Not	Not
Exceeded			Exceeded	I,L=0	I,L=0	Exceeded	Exceeded	Exceeded	Exceeded
Average	1999	419	0 010	0 140		0 003	< 0 0002		0 003
High	1999	457	0 010	0 140		0 005	< 0 0002		0 003
Low	1999	378	0 010	0 140		0 002	< 0 0002		0 003
N Samples	1999	3	3	1		3	3		3
Objectives	1999	D=3	Not	A=1		Not	Not		Not
Exceeded			Exceeded	I,L=0		Exceeded	Exceeded		Exceeded
Objectives									
Public Health									
Drinking Water (D)		200 Aesthetic				0 025	0 005	0 005	1 0 Aesthetic
Recreation (R)									
Aquatic Life (A)			0 1*	0 1*	0 1*	0 15 & 0 34	Calculated (Q7)	Calculated (Q7)	Calculated (Q7)
Irrigation (I)						0 1	0 0051	0 0051	0 2-1 0
Greenhouse (GI)			5 0	5 0	5 0				
Field Crop (FI)									
Livestock (L)			5 0	5 0	5 0	0 025	0 08	0 08	0 5-5 0
Promotes Nuisance Plants (P)									

Used for CWQI

*Calculated for pH over 6.5.

Canadian Water Quality Index

Appendix 1. Cont'd.

Statistic	Date	Copper Extractable	Chromium Hexavalent	Lead Total	Lead Extractable	Nickel Total	Nickel Extractable	Zinc Total	Zinc Extractable
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Average	1990	< 0.011	< 0.02		< 0.0029		< 0.005		< 0.01
High	1990	0.020	< 0.02		< 0.0050		0.005		0.02
Low	1990	< 0.010	< 0.02		< 0.0020		< 0.005		< 0.01
N Samples	1990	7	7		7		7		7
Objectives	1990	Not	Not		Not		Not		Not
Exceeded		Exceeded	Detected		Exceeded		Exceeded		Exceeded
Average	1991	< 0.010	< 0.02		< 0.0021		< 0.005		< 0.01
High	1991	< 0.010	< 0.02		0.0030		< 0.005		0.01
Low	1991	< 0.010	< 0.02		< 0.0020		< 0.005		< 0.01
N Samples	1991	9	9		9		9		9
Objectives	1991	Not	Not		Not		Not		Not
Exceeded		Exceeded	Detected		Exceeded		Exceeded		Exceeded
Average	1992	< 0.011	< 0.02		< 0.0020		< 0.005		< 0.01
High	1992	0.020	< 0.02		< 0.0020		0.005		0.02
Low	1992	< 0.010	< 0.02		< 0.0020		< 0.005		< 0.01
N Samples	1992	12	12		12		12		11
Objectives	1992	Not	Not		Not		Not		Not
Exceeded		Exceeded	Detected		Exceeded		Exceeded		Exceeded
Average	1993	< 0.010	< 0.02		< 0.0020		< 0.005		< 0.01
High	1993	0.010	< 0.02		0.0020		0.006		0.02
Low	1993	< 0.010	< 0.02		< 0.0020		< 0.005		< 0.01
N Samples	1993	12	12		12		12		12
Objectives	1993	Not	Not		A=1		Not		Not
Exceeded		Exceeded	Detected		D,I=0		Exceeded		Exceeded
Average	1994	< 0.010	< 0.02		< 0.0020		< 0.005		< 0.01
High	1994	< 0.010	< 0.02		< 0.0020		< 0.005		0.02
Low	1994	< 0.010	< 0.02		< 0.0020		< 0.005		< 0.01
N Samples	1994	7	7		7		7		7
Objectives	1994	Not	Not		Not		Not		Not
Exceeded		Exceeded	Detected		Exceeded		Exceeded		Exceeded
Average	1995	< 0.010	< 0.02		< 0.0020		< 0.005		< 0.01
High	1995	< 0.010	< 0.02		< 0.0020		< 0.005		0.01
Low	1995	< 0.010	< 0.02		< 0.0020		< 0.005		< 0.01
N Samples	1995	12	12		12		12		12
Objectives	1995	Not	Not		Not		Not		Not
Exceeded		Exceeded	Detected		Exceeded		Exceeded		Exceeded
Average	1996	< 0.008	< 0.02		< 0.0018		< 0.005		< 0.02
High	1996	0.010	< 0.02		< 0.0020		< 0.005		0.07
Low	1996	< 0.005	< 0.02		< 0.0010		0.003		< 0.01
N Samples	1996	10	10		10		10		10
Objectives	1996	A=1	Not		Not		Not		A=1
Exceeded		D,I=0	Detected		Exceeded		Exceeded		D,I=0
Average	1997	< 0.010	< 0.02	< 0.0010	< 0.0010	0.008	< 0.003	< 0.01	< 0.01
High	1997	0.027	< 0.02	0.0010	0.0010	0.017	0.005	0.01	0.01
Low	1997	< 0.005	< 0.02	< 0.0010	< 0.0010	0.003	< 0.002	< 0.01	< 0.01
N Samples	1997	12	12	3	12	3	12	3	9
Objectives	1997	A=1	Not	Not	Not	Not	Not	Not	Not
Exceeded		D,I=0	Detected	Exceeded	Exceeded	Exceeded	Exceeded	Exceeded	Exceeded
Average	1998	< 0.005	< 0.02	< 0.0011	< 0.0010	< 0.004	< 0.003	< 0.01	< 0.01
High	1998	0.006	< 0.02	0.0020	0.0010	0.007	0.004	0.02	0.01
Low	1998	< 0.005	< 0.02	< 0.0005	< 0.0010	< 0.002	< 0.002	< 0.01	< 0.01
N Samples	1998	6	8	8	6	8	8	8	6
Objectives	1998	Not	Not	Not	Not	Not	Not	Not	Not
Exceeded		Exceeded	Detected	Exceeded	Exceeded	Exceeded	Exceeded	Exceeded	Exceeded
Average	1999		< 0.02	< 0.0005		0.007		< 0.02	
High	1999		< 0.02	< 0.0005		0.013		0.02	
Low	1999		< 0.01	< 0.0005		0.004		< 0.02	
N Samples	1999		3	3		3		3	
Objectives	1999		Not	Not		Not		Not	
Exceeded			Detected	Exceeded		Exceeded		Exceeded	
Objectives									
Public Health									
Drinking Water (D)		1.0 Aesthetic		0.01	0.01			5.0 Aesthetic	5.0 Aesthetic
Recreation (R)									
Aquatic Life (A)		Calculated (Q7)	0.011 & 0.016*	Calculated (Q7)	Calculated (Q7)	Calculated (Q7)	Calculated (Q7)	Calculated (Q7)	Calculated (Q7)
Irrigation (I)		0.2-1.0		0.20	0.20	200	200	1.0-5.0	1.0-5.0
Greenhouse (GI)									
Field Crop (FI)									
Livestock (L)		0.5-5.0		0.10		1000	1000	5.0	5.0
Promotes Nuisance Plants (P)									

Used for CWQI

Canadian Water Quality Index

* Below detection limits

Appendix 1. Cont'd.

Statistic	Date	Iron Total	Iron Extractable	Manganese Total	Manganese Extractable	2, 4-D	2, 4-DB	2, 4-DP	2, 4, 5-T	2, 4, 5-TP	Alachlor
Units		mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Average	1990		0 15		0 0443	0 19		0 11			
High	1990		0 26		0 0600	0 67		0 11			
Low	1990		0 12		0 0200	< 0 05		0 11			
N Samples	1990		7		7	7		1			
Objectives	1990		Not		D=3	Not		Not			
Exceeded			Exceeded		I=0	Exceeded		Exceeded			
Average	1991		0 22		< 0 0400	0 15		0 13	< 0 01		
High	1991		0 42		0 0900	0 32		0 36	< 0 01		
Low	1991		0 04		< 0 0200	< 0 05		< 0 10	< 0 01		
N Samples	1991		9		9	9		9	9		
Objectives	1991		D,A=3		D=2	Not		Not	Not		
Exceeded			I=0		I=0	Exceeded		Exceeded	Exceeded		
Average	1992		0 34		0 5142	0 73	< 0 2	< 0 10	< 0 01	< 0 01	< 2 0
High	1992		0 85		2 1100	7 70	< 0 2	< 0 10	< 0 01	< 0 01	< 2 0
Low	1992		0 08		0 0200	< 0 05	< 0 2	< 0 10	< 0 01	< 0 01	< 2 0
N Samples	1992		12		12	12	6	12	12	12	6
Objectives	1992		D,A=6		D=6	Not	Not	Not	Not	Not	Not
Exceeded			I=0		I=4	Exceeded	Exceeded	Exceeded	Exceeded	Exceeded	Detected
Average	1993		0 63		< 0 4050	0 11	0 24	0 10	< 0 01	< 0 01	< 2 0
High	1993		2 39		2 2000	0 34	0 72	0 11	< 0 01	< 0 01	< 2 0
Low	1993		0 06		< 0 0200	< 0 05	< 0 2	< 0 10	< 0 01	< 0 01	< 2 0
N Samples	1993		12		12	12	12	12	12	12	12
Objectives	1993		D,A=3		D=7	Not	Not	Not	Not	Not	Not
Exceeded			I=0		I=2	Exceeded	Exceeded	Exceeded	Exceeded	Exceeded	Detected
Average	1994		0 14		< 0 0300	0 14	< 0 2	< 0 10			< 2 0
High	1994		0 33		0 0700	0 41	< 0 2	< 0 10			< 2 0
Low	1994		0 05		< 0 0200	< 0 05	< 0 2	< 0 10			< 2 0
N Samples	1994		7		7	7	7	7			7
Objectives	1994		D,A=1		D=1	Not	Not	Not			Not
Exceeded			I=0		I=0	Exceeded	Exceeded	Exceeded			Detected
Average	1995		0 14		< 0 0557	0 08	< 0 2	< 0 10			< 2 0
High	1995		0 28		0 2300	0 17	< 0 2	< 0 10			< 2 0
Low	1995		0 01		< 0 0050	< 0 05	< 0 2	< 0 10			< 2 0
N Samples	1995		12		12	12	12	12			12
Objectives	1995		Not		D=3	Not	Not	Not			Not
Exceeded			Exceeded		I=1	Exceeded	Exceeded	Exceeded			Detected
Average	1996		0 53		0 3396	0 24	< 0 2	0 11			< 2 0
High	1996		1 83		1 7200	1 40	< 0 2	0 17			< 2 0
Low	1996		0 08		0 0160	< 0 05	< 0 2	< 0 10			< 2 0
N Samples	1996		10		10	10	10	10			10
Objectives	1996		D,A=4		D=4	Not	Not	Not			Not
Exceeded			I=0		I=2	Exceeded	Exceeded	Exceeded			Detected
Average	1997	0 55	0 26	0 0317	0 3163	0 10	< 0 14	0 09			< 1 1
High	1997	0 64	0 59	0 0610	1 3400	0 65	< 0 2	0 20			< 2 0
Low	1997	0 42	0 04	0 0110	0 0050	0 05	< 0 05	< 0 05			< 2 0
N Samples	1997	3	12	3	12	12	12	12			12
Objectives	1997	12	D,A=3	D=1	D=4	Not	Not	Not			Not
Exceeded		D,A=3	I=0	I=0	I=3	Exceeded	Exceeded	Exceeded			Detected
Average	1998	0 46	0 22	0 0557	0 0571	0 14	< 0 05	0 06			< 2 0
High	1998	0 85	0 31	0 1410	0 1410	0 51	< 0 05	0 09			< 2 0
Low	1998	0 17	0 14	0 0205	0 0205	< 0 05	< 0 05	< 0 05			< 2 0
N Samples	1998	8	6	8	7	6	6	6			6
Objectives	1998	12	D,A=1	D=2	D=2	Not	Not	Not			Not
Exceeded		D,A=6	I=0	I=0	I=0	Exceeded	Exceeded	Exceeded			Detected
Average	1999	0 37		0 0499		0 12	< 0 05	< 0 05			< 2 0
High	1999	0 65		0 0823		0 27	< 0 05	< 0 05			< 2 0
Low	1999	0 19		0 0215		< 0 05	< 0 05	< 0 05			< 2 0
N Samples	1999	8		8		3	3	3			3
Objectives	1999	D,A=4		D=4		Not	Not	Not			Not
Exceeded		I=0		I=0		Exceeded	Exceeded	Exceeded			Detected
Objectives											
Public Health											
Drinking Water (D)		0 3 Aesthetic	0 3 Aesthetic	0 05 Aesthetic	0 05 Aesthetic	100	100	100			Unlisted
Recreation (R)											
Aquatic Life (A)		0 3	0 3			4	4	4	4	4	
Irrigation (I)		5 0	5 0	0 2	0 2						
Greenhouse (GI)											
Field Crop (FI)											
Livestock (L)						100	100	100	100	100	
Promotes Nuisance Plants (P)											

Used for CWQI

Canadian Water Quality Index

Appendix 1. Cont'd.

Statistic Units	Date	Aldrin ug/L	Atrazine ug/L	Azinphos-Methyl ug/L	Bromacil ug/L	Bromoxynil ug/L	Carbofuran ug/L	Chlordane Cis- ug/L	Chlordane Trans- ug/L	Chlorpyrifos-Ethyl ug/L
Average	1990		< 0.5		< 1.0	0.01				
High	1990		< 0.5		< 1.0	0.02				
Low	1990		< 0.5		< 1.0	< 0.01				
N Samples	1990		7		7	7				
Objectives	1990		Not		Not	Not				
Exceeded			Exceeded		Detected	Exceeded				
Average	1991		< 0.5		< 1.0	< 0.02				
High	1991		< 0.5		< 1.0	0.07				
Low	1991		< 0.5		< 1.0	< 0.01				
N Samples	1991		9		9	9				
Objectives	1991		Not		Not	Not				
Exceeded			Exceeded		Detected	Exceeded				
Average	1992	< 0.01	< 0.5	< 1.5	< 1.0	0.08	< 2.0	< 0.01	< 0.01	< 0.8
High	1992	< 0.01	< 0.5	< 1.5	< 1.0	0.84	< 2.0	< 0.01	< 0.01	< 0.8
Low	1992	< 0.01	< 0.5	< 1.5	< 1.0	< 0.01	< 2.0	< 0.01	< 0.01	< 0.8
N Samples	1992	6	12	4	12	12	6	12	12	4
Objectives	1992	Not	Not	Not	Not	D.A.L =0	Not	Not	Not	Not
Exceeded		Exceeded	Exceeded	Exceeded	Detected	I = 1	Detected	Detected	Detected	Detected
Average	1993	< 0.01	< 0.5	< 1.5	< 1.0	< 0.01	< 2.0	< 0.01	< 0.01	< 0.8
High	1993	< 0.01	< 0.5	< 1.5	< 1.0	< 0.01	< 2.0	< 0.01	< 0.01	< 0.8
Low	1993	< 0.01	< 0.5	< 1.5	< 1.0	< 0.01	< 2.0	< 0.01	< 0.01	< 0.8
N Samples	1993	12	12	12	12	12	12	12	12	12
Objectives	1993	Not	Not	Not	Not	Not	Not	Not	Not	Not
Exceeded		Exceeded	Exceeded	Exceeded	Detected	Exceeded	Detected	Detected	Detected	Detected
Average	1994	< 0.01	< 0.5	< 1.5	< 1.0	< 0.05	< 2.0	< 0.01	< 0.01	< 0.8
High	1994	< 0.01	< 0.5	< 1.5	< 1.0	0.26	< 2.0	< 0.01	< 0.01	< 0.8
Low	1994	< 0.01	< 0.5	< 1.5	< 1.0	< 0.01	< 2.0	< 0.01	< 0.01	< 0.8
N Samples	1994	2	7	2	7	7	7	7	7	7
Objectives	1994	Not	Not	Not	Not	Not	Not	Not	Not	Not
Exceeded		Exceeded	Exceeded	Exceeded	Detected	Exceeded	Detected	Detected	Detected	Detected
Average	1995		< 0.5		< 1.0	< 0.01	< 2.0	< 0.01	< 0.01	< 0.8
High	1995		< 0.5		< 1.0	< 0.01	< 2.0	< 0.01	< 0.01	< 0.8
Low	1995		< 0.5		< 1.0	< 0.01	< 2.0	< 0.01	< 0.01	< 0.8
N Samples	1995		12		12	12	12	12	12	12
Objectives	1995		Not		Not	Not	Not	Not	Not	Not
Exceeded			Exceeded		Detected	Exceeded	Detected	Detected	Detected	Detected
Average	1996		< 0.5		< 1.0	0.04	< 2.0	< 0.01	< 0.01	< 0.8
High	1996		< 0.5		< 1.0	0.24	< 2.0	< 0.01	< 0.01	< 0.8
Low	1996		< 0.5		< 1.0	< 0.01	< 2.0	< 0.01	< 0.01	< 0.8
N Samples	1996		10		10	10	10	10	10	10
Objectives	1996		Not		Not	Not	Not	Not	Not	Not
Exceeded			Exceeded		Detected	Exceeded	Detected	Detected	Detected	Detected
Average	1997		< 0.3		< 0.6	< 0.02	< 2.0	< 0.01	< 0.01	< 0.5
High	1997		< 0.5		< 1.0	< 0.02	< 2.0	< 0.01	< 0.01	< 0.8
Low	1997		< 0.1		< 0.2	< 0.01	< 2.0	< 0.01	< 0.01	< 0.1
N Samples	1997		12		12	12	12	12	12	12
Objectives	1997		Not		Not	Not	Not	Not	Not	Not
Exceeded			Exceeded		Detected	Exceeded	Detected	Detected	Detected	Detected
Average	1998		< 0.1		< 0.2	< 0.02	< 2.0	< 0.01	< 0.01	< 0.1
High	1998		< 0.1		< 0.2	< 0.02	< 2.0	< 0.01	< 0.01	< 0.1
Low	1998		< 0.1		< 0.2	< 0.02	< 2.0	< 0.01	< 0.01	< 0.1
N Samples	1998		6		6	6	6	7	7	6
Objectives	1998		Not		Not	Not	Not	Not	Not	Not
Exceeded			Exceeded		Exceeded	Exceeded	Detected	Detected	Detected	Detected
Average	1999		< 0.1		< 0.2	< 0.02	< 2.0	< 0.01	< 0.01	< 0.1
High	1999		< 0.1		< 0.2	< 0.02	< 2.0	< 0.01	< 0.01	< 0.1
Low	1999		< 0.1		< 0.2	< 0.02	< 2.0	< 0.01	< 0.01	< 0.1
N Samples	1999		3		3	3	3	3	3	3
Objectives	1999		Not		Not	Not	Not	Not	Not	Not
Exceeded			Exceeded		Exceeded	Exceeded	Detected	Detected	Detected	Detected
Objectives										
Public Health										
Drinking Water (D)		0.7	5	20	5	5	90	Sediment Concentration Only	Sediment Concentration Only	90
Recreation (R)										
Aquatic Life (A)			1.8			5	1.8			0.0035
Irrigation (I)			10		0.2	0.33				
Greenhouse (GI)										
Field Crop (FI)										
Livestock (L)			5		1100	11	45			24
Promotes Nuisance Plants (P)										

Used for CWQI

Canadian Water Quality Index

Appendix 1. Cont'd.

Statistic Units	Date	Chlorothalonil ug/L	DDD p,p ug/L	DDE p,p ug/L	DDT p,p ug/L	Deltamethrin ug/L	Diazinon ug/L	Dicamba ug/L	Diclofop ug/L	Diclofop-Methyl ug/L
Average	1990							< 0.07		< 0.09
High	1990							0.21		< 0.09
Low	1990							< 0.02		< 0.09
N Samples	1990							7		7
Objectives	1990							D,A,L=0		Not
Exceeded								I=3		Exceeded
Average	1991							< 0.05		< 0.09
High	1991							0.14		< 0.09
Low	1991							< 0.02		< 0.09
N Samples	1991							9		9
Objectives	1991							D,A,L=0		Not
Exceeded								I=4		Exceeded
Average	1992		< 0.03	< 0.01	< 0.03		< 0.5	< 0.02		< 0.09
High	1992		< 0.03	< 0.01	< 0.03		< 0.5	< 0.02		< 0.09
Low	1992		< 0.03	< 0.01	< 0.03		< 0.5	< 0.02		< 0.09
N Samples	1992		6	6	6		4	12		12
Objectives	1992		Not	Not	Not		Not	Not		Not
Exceeded			Detected	Detected	Detected		Detected	Detected		Exceeded
Average	1993		< 0.03	< 0.01	< 0.03		< 0.5	< 0.02		< 0.09
High	1993		< 0.03	< 0.01	< 0.03		< 0.5	< 0.02		< 0.09
Low	1993		< 0.03	< 0.01	< 0.03		< 0.5	< 0.02		< 0.09
N Samples	1993		12	12	12		12	12		12
Objectives	1993		Not	Not	Not		Not	Not		Not
Exceeded			Detected	Detected	Detected		Detected	Detected		Exceeded
Average	1994		< 0.03	< 0.01	< 0.03		< 0.5	< 0.04		< 0.09
High	1994		< 0.03	< 0.01	< 0.03		< 0.5	0.12		< 0.09
Low	1994		< 0.03	< 0.01	< 0.03		< 0.5	< 0.02		< 0.09
N Samples	1994		2	2	2		2	7		7
Objectives	1994		Not	Not	Not		Not	D,A,L=0		Not
Exceeded			Detected	Detected	Detected		Detected	I=2		Exceeded
Average	1995					< 0.04		< 0.03		< 0.09
High	1995					< 0.04		0.08		< 0.09
Low	1995					< 0.04		< 0.02		< 0.09
N Samples	1995					4		12		12
Objectives	1995					Not		D,A,L=0		Not
Exceeded						Detected		I=4		Exceeded
Average	1996	< 5.0				< 0.04		< 0.04		< 0.09
High	1996	< 5.0				< 0.04		0.19		< 0.09
Low	1996	< 5.0				< 0.04		< 0.02		< 0.09
N Samples	1996	8				10		10		10
Objectives	1996	Not				Not		D,A,L=0		Not
Exceeded		Detected				Detected		I=1		Exceeded
Average	1997	< 2.8				< 0.04	< 0.1	< 0.02	0.1	< 0.09
High	1997	< 5.0				< 0.04	< 0.1	< 0.02	< 0.2	< 0.09
Low	1997	< 0.5				< 0.04	< 0.1	< 0.02	< 0.1	< 0.09
N Samples	1997	12				12	6	12	6	12
Objectives	1997	Not				Not	Not	Not	Not	Not
Exceeded		Detected				Detected	Detected	Detected	Detected	Exceeded
Average	1998	< 0.5				< 0.04	< 0.1	< 0.03	< 0.1	< 0.09
High	1998	< 0.5				< 0.04	< 0.1	0.07	< 0.1	< 0.09
Low	1998	< 0.5				< 0.04	< 0.1	< 0.02	< 0.1	< 0.09
N Samples	1998	6				7	6	6	6	6
Objectives	1998	Not				Not	Not	D,A,L=0	Not	Not
Exceeded		Detected				Detected	Detected	I=1	Detected	Exceeded
Average	1999	< 0.5				< 0.04	< 0.1	< 0.02	< 0.1	< 0.09
High	1999	< 0.5				< 0.04	< 0.1	< 0.02	< 0.1	< 0.09
Low	1999	< 0.5				< 0.04	< 0.1	< 0.02	< 0.1	< 0.09
N Samples	1999	3				3	3	3	3	3
Objectives	1999	Not				Not	Not	Not	Not	Not
Exceeded		Detected				Detected	Detected	Detected	Detected	Exceeded
Objectives										
Public Health			Sediment	Sediment	Sediment					
Drinking Water (D)			Concentration	Concentration	Concentration		2.5	120	See	9
Recreation (R)			Only	Only	Only				Diclofop-Methyl	
Aquatic Life (A)		0.18				0.004		10		6.1
Irrigation (I)		5.8						0.006		0.18
Greenhouse (GI)										
Field Crop (FI)										
Livestock (L)		170				2.5		122		9
Promotes Nuisance Plants (P)										

Used for CWQI

Canadian Water Quality Index

Appendix 1. Cont'd.

Statistic Units	Date	Dieldrin ug/L	Dimethoate ug/L	Dinoseb ug/L	Endosulfan I ug/L	Endrin ug/L	Eptam ug/L	Ethfluralin ug/L	Fenoxaprop ug/L	HCH Alpha ug/L
Average	1990									
High	1990									
Low	1990									
N Samples	1990									
Objectives	1990									
Exceeded										
Average	1991			< 0.05						
High	1991			< 0.05						
Low	1991			< 0.05						
N Samples	1991			9						
Objectives	1991			Not						
Exceeded				Exceeded						
Average	1992	< 0.02	< 1.0	< 0.05	< 0.01	< 0.02				< 0.02
High	1992	< 0.02	< 1.0	< 0.05	< 0.01	< 0.02				< 0.02
Low	1992	< 0.02	< 1.0	< 0.05	< 0.01	< 0.02				< 0.02
N Samples	1992	6	4	12	6	6				12
Objectives	1992	Not	Not	Not	Not	Not				Not
Exceeded		Exceeded	Exceeded	Exceeded	Exceeded	Detected				Detected
Average	1993	< 0.02	< 1.0	< 0.05	< 0.01	< 0.02				< 0.02
High	1993	< 0.02	< 1.0	< 0.05	< 0.01	< 0.02				< 0.02
Low	1993	< 0.02	< 1.0	< 0.05	< 0.01	< 0.02				< 0.02
N Samples	1993	12	12	12	12	12				12
Objectives	1993	Not	Not	Not	Not	Not				Not
Exceeded		Exceeded	Exceeded	Exceeded	Exceeded	Detected				Detected
Average	1994	< 0.02	< 1.0		< 0.01	< 0.02				< 0.02
High	1994	< 0.02	< 1.0		< 0.01	< 0.02				< 0.02
Low	1994	< 0.02	< 1.0		< 0.01	< 0.02				< 0.02
N Samples	1994	2	7		2	2				2
Objectives	1994	Not	Not		Not	Not				Not
Exceeded		Exceeded	Exceeded		Exceeded	Detected				Detected
Average	1995		< 1.0					< 0.02		
High	1995		< 1.0					< 0.02		
Low	1995		< 1.0					< 0.02		
N Samples	1995		12					4		
Objectives	1995		Not					Not		
Exceeded			Exceeded					Detected		
Average	1996		< 1.0				< 5.0	< 0.02		
High	1996		< 1.0				< 5.0	< 0.02		
Low	1996		< 1.0				< 5.0	< 0.02		
N Samples	1996		10				8	10		
Objectives	1996		Not				Not	Not		
Exceeded			Exceeded				Detected	Detected		
Average	1997		< 0.6	< 0.08			< 2.6	< 0.02	< 0.1	
High	1997		< 1.0	< 0.2			< 5.0	< 0.02	< 0.2	
Low	1997		< 0.2	< 0.05			< 0.2	< 0.02	< 0.1	
N Samples	1997		12	6			12	12	6	
Objectives	1997		Not	Not			Not	Not	Not	
Exceeded			Exceeded	Detected			Detected	Detected	Exceeded	
Average	1998		< 0.2	< 0.05			< 0.2	< 0.02	< 0.1	
High	1998		< 0.2	< 0.05			< 0.2	< 0.02	< 0.1	
Low	1998		< 0.2	< 0.05			< 0.2	< 0.02	< 0.1	
N Samples	1998		6	6			6	6	6	
Objectives	1998		Not	Not			Not	Not	Not	
Exceeded			Exceeded	Exceeded			Detected	Detected	Exceeded	
Average	1999		< 0.2	< 0.05			< 0.2	< 0.02	< 0.1	
High	1999		< 0.2	< 0.05			< 0.2	< 0.02	< 0.1	
Low	1999		< 0.2	< 0.05			< 0.2	< 0.02	< 0.1	
N Samples	1999		3	3			3	3	3	
Objectives	1999		Not	Not			Not	Not	Not	
Exceeded			Exceeded	Exceeded			Detected	Detected	Exceeded	
Objectives										
Public Health						Sediment				Sediment
Drinking Water (D)		0.7	20	10		Concentration	Unlisted	Unlisted		Concentration
Recreation (R)						Only				Only
Aquatic Life (A)			6.2	0.05	0.02				4	
Irrigation (I)				16						
Greenhouse (GI)										
Field Crop (FI)										
Livestock (L)			3	150					100	
Promotes Nuisance Plants (P)										

Used for CWQI

Canadian Water Quality Index

Appendix 1. Cont'd.

Statistic	Date	HCH Beta	HCH Delta	Lindane (HCH Gamma)	Heptachlor	Heptaclor Epoxide	Malathion	MCPA	Mecoprop	Methxychlor p,p
Units		ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Average	1990			< 0.02				< 10.0		
High	1990			< 0.02				< 10.0		
Low	1990			< 0.02				< 10.0		
N Samples	1990			7				7		
Objectives	1990			Not				Not		
Exceeded				Detected				Detected		
Average	1991			< 0.02				< 10.0		
High	1991			< 0.02				< 10.0		
Low	1991			< 0.02				< 10.0		
N Samples	1991			9				9		
Objectives	1991			Not				Not		
Exceeded				Detected				Detected		
Average	1992	< 0.03	< 0.01	< 0.02	< 0.02	< 0.01	< 0.9	< 10.0		< 0.04
High	1992	< 0.03	< 0.01	< 0.02	< 0.02	< 0.01	< 0.9	< 10.0		< 0.04
Low	1992	< 0.03	< 0.01	< 0.02	< 0.02	< 0.01	< 0.9	< 10.0		< 0.04
N Samples	1992	12	12	12	6	6	4	12		12
Objectives	1992	Not	Not	Not	Not	Not	Not	Not		Not
Exceeded		Detected	Detected	Detected	Detected	Detected	Exceeded	Detected		Exceeded
Average	1993	< 0.03	< 0.01	< 0.02	< 0.02	< 0.01	< 0.9	11.42		< 0.04
High	1993	< 0.03	< 0.01	< 0.02	< 0.02	< 0.01	< 0.9	27.0		0.04
Low	1993	< 0.03	< 0.01	< 0.02	< 0.02	< 0.01	< 0.9	< 10.0		< 0.04
N Samples	1993	12	12	12	12	12	12	12		12
Objectives	1993		Not	Not	Not	Not	Not	I, A, L=1		Not
Exceeded			Detected	Detected	Detected	Detected	Exceeded			Exceeded
Average	1994	< 0.03	< 0.01	< 0.02	< 0.02	< 0.01	< 0.9	<11		< 0.04
High	1994	< 0.03	< 0.01	0.02	< 0.02	< 0.01	< 0.9	15.0		< 0.04
Low	1994	< 0.03	< 0.01	< 0.02	< 0.02	< 0.01	< 0.9	< 10.0		< 0.04
N Samples	1994	2	2	7	2	2	7	7		7
Objectives	1994	Not	Not	Not			Not	I, A, L=2		Not
Exceeded		Detected	Detected	Exceeded			Exceeded			Exceeded
Average	1995			< 0.02			< 0.9	< 10.0		< 0.04
High	1995			< 0.02			< 1.0	< 10.0		< 0.04
Low	1995			< 0.02			< 0.9	< 10.0		< 0.04
N Samples	1995			12			12	12		12
Objectives	1995			Not			Not	Not		Not
Exceeded				Detected			Exceeded	Detected		Exceeded
Average	1996			< 0.02			< 0.9	< 10.0		< 0.04
High	1996			< 0.02			< 0.9	< 10.0		< 0.04
Low	1996			< 0.02			< 0.9	< 10.0		< 0.04
N Samples	1996			10			10	< 10.0		10
Objectives	1996			Not			Not	Not		Not
Exceeded				Detected			Exceeded	Detected		Exceeded
Average	1997			< 0.02			< 0.6	< 5.0	< 0.08	< 0.04
High	1997			0.03			< 0.9	< 10.0	< 0.20	0.06
Low	1997			< 0.02			< 0.2	< 0.05	< 0.05	< 0.04
N Samples	1997			12			12	12	6	12
Objectives	1997			Not			Not	Not	Not	Not
Exceeded				Exceeded			Exceeded	Detected	Exceeded	Exceeded
Average	1998			< 0.02			< 0.2	< 0.06	< 0.05	< 0.04
High	1998			< 0.02			< 0.2	0.11	< 0.05	< 0.04
Low	1998			< 0.02			< 0.2	< 0.05	< 0.05	< 0.04
N Samples	1998			7			6	6	6	7
Objectives	1998			Not			Not	I=1	Not	Not
Exceeded				Detected			Exceeded	A, L=0	Exceeded	Exceeded
Average	1999			< 0.02			< 0.2	< 0.05	< 0.05	< 0.04
High	1999			< 0.02			< 0.2	< 0.05	< 0.05	< 0.04
Low	1999			< 0.02			< 0.2	< 0.05	< 0.05	< 0.04
N Samples	1999			3			3	3	3	3
Objectives	1999			Not			Not	Not	Not	Not
Exceeded				Detected			Exceeded	Detected	Exceeded	Exceeded
Objectives										
Public Health		Sediment	Sediment	Sediment	Sediment	Sediment				
Drinking Water (D)		Concentration	Concentration	Concentration	Concentration	Concentration	190			900
Recreation (R)		Only	Only	Only	Only	Only				
Aquatic Life (A)				0.06				2.6	4	
Irrigation (I)				Old Objective				0.025		
Greenhouse (GI)										
Field Crop (FI)										
Livestock (L)								25	100	
Promotes Nuisance Plants (P)										

Used for CWQI

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Appendix 1. Cont'd.

Statistic	Date	Metribuzin	Mirex	Parathion Ethyl	Parathion Methyl	Pentachlorophenol	Picloram	Propachlor	Propanil	Propoxur
Units		ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Average	1990	< 1.0					< 0.2	< 2.0	< 2.0	
High	1990	< 1.0					< 0.2	< 2.0	< 2.0	
Low	1990	< 1.0					< 0.2	< 2.0	< 2.0	
N Samples	1990	7					7	7	7	
Objectives	1990	Not					Not	Not	Not	
Exceeded		Detected					Exceeded	Detected	Detected	
Average	1991	< 1.0					< 0.2	< 2.0	< 2.0	
High	1991	< 1.0					< 0.2	< 2.0	< 2.0	
Low	1991	< 1.0					< 0.2	< 2.0	< 2.0	
N Samples	1991	9					9	9	9	
Objectives	1991	Not					Not	Not	Not	
Exceeded		Detected					Exceeded	Detected	Detected	
Average	1992	< 1.0	< 0.02	< 0.9	< 0.6		< 0.2	< 2.0	< 2.0	< 2.0
High	1992	< 1.0	< 0.02	< 0.9	< 0.6		< 0.2	< 2.0	< 2.0	< 2.0
Low	1992	< 1.0	< 0.02	< 0.9	< 0.6		< 0.2	< 2.0	< 2.0	< 2.0
N Samples	1992	12	6	4	4		12	12	12	6
Objectives	1992	Not	Not	Not	Not		Not	Not	Not	Not
Exceeded		Detected	Detected	Detected	Detected		Exceeded	Detected	Detected	Detected
Average	1993	< 1.0	< 0.02	< 0.9	< 0.6		< 0.2	< 2.0	< 2.0	< 2.0
High	1993	< 1.0	< 0.02	< 0.9	< 0.6		< 0.2	< 2.0	< 2.0	< 2.0
Low	1993	< 1.0	< 0.02	< 0.9	< 0.6		< 0.2	< 2.0	< 2.0	< 2.0
N Samples	1993	12	12	12	12		12	12	12	12
Objectives	1993	Not	Not	Not	Not		Not	Not	Not	Not
Exceeded		Detected	Detected	Detected	Detected		Exceeded	Detected	Detected	Detected
Average	1994	< 1.0	< 0.02	< 0.9	< 0.6		< 0.2	< 2.0	< 2.0	< 2.0
High	1994	< 1.0	< 0.02	< 0.9	< 0.6		< 0.2	< 2.0	< 2.0	< 2.0
Low	1994	< 1.0	< 0.02	< 0.9	< 0.6		< 0.2	< 2.0	< 2.0	< 2.0
N Samples	1994	7	2	2	2		7	2	7	7
Objectives	1994	Not	Not	Not	Not		Not	Not	Not	Not
Exceeded		Detected	Detected	Detected	Detected		Exceeded	Detected	Detected	Detected
Average	1995	< 1.0					< 0.2		< 2.0	< 2.0
High	1995	< 1.0					< 0.2		< 2.0	< 2.0
Low	1995	< 1.0					< 0.2		< 2.0	< 2.0
N Samples	1995	12					12		12	12
Objectives	1995	Not					Not		Not	Not
Exceeded		Detected					Exceeded		Detected	Detected
Average	1996	< 1.0					< 0.2		< 2.0	< 2.0
High	1996	< 1.0					< 0.2		< 2.0	< 2.0
Low	1996	< 1.0					< 0.2		< 2.0	< 2.0
N Samples	1996	10					10		10	10
Objectives	1996	Not					Not		Not	Not
Exceeded		Detected					Exceeded		Detected	Detected
Average	1997	< 0.6				< 0.05	< 0.2		< 1.1	1.1
High	1997	< 1.0				< 0.20	< 0.2		< 2.0	< 2.0
Low	1997	< 0.2				< 0.02	< 0.2		< 0.2	0.2
N Samples	1997	12				6	12		12	12
Objectives	1997	Not				Not	Not		Not	Not
Exceeded		Detected				Exceeded	Exceeded		Detected	Detected
Average	1998	< 0.2				< 0.02	< 0.2		< 0.2	< 0.2
High	1998	< 0.2				< 0.02	< 0.2		< 0.2	< 0.2
Low	1998	< 0.2				< 0.02	< 0.2		< 0.2	< 0.2
N Samples	1998	6				6	6		6	6
Objectives	1998	Not				Not	Not		Not	Not
Exceeded		Exceeded				Exceeded	Exceeded		Detected	Detected
Average	1999	< 0.2				< 0.02	< 0.2		< 0.2	< 0.2
High	1999	< 0.2				< 0.02	< 0.2		< 0.2	< 0.2
Low	1999	< 0.2				< 0.02	< 0.2		< 0.2	< 0.2
N Samples	1999	3				3	3		3	3
Objectives	1999	Not				Not	Not		Not	Not
Exceeded		Exceeded				Exceeded	Exceeded		Detected	Detected
Objectives										
Public Health						30 Aesthetic				
Drinking Water (D)		80	Unlisted	50 for	50 for	60 Drinking	190	Unlisted	Unlisted	Unlisted
Recreation (R)				Total Parathion	Total Parathion					
Aquatic Life (A)		1.0				0.5	29			
Irrigation (I)		0.5								
Greenhouse (GI)										
Field Crop (FI)										
Livestock (L)		80					190			
Promotes Nuisance Plants (P)										

Used for CWQI

Canadian Water Quality Index

Appendix 1. Cont'd.

Statistic Units	Date	Quizlofop ug/L	Simazine ug/L	Terbufos ug/L	Triallate ug/L	Triclopyr ug/L	Trifluralin ug/L
Average	1990		< 0.5		< 1.0		< 0.03
High	1990		< 0.5		< 1.0		< 0.03
Low	1990		< 0.5		< 1.0		< 0.03
N Samples	1990		7		7		7
Objectives	1990		Not		Not		Not
Exceeded			Exceeded		Detected		Exceeded
Average	1991		1.1		< 1.0	0.05	< 0.03
High	1991		< 5.2		< 1.0	0.05	< 0.03
Low	1991		< 0.5		< 1.0	0.05	< 0.03
N Samples	1991		9		9	1	9
Objectives	1991		I=2		Not	Detected = 1	Not
Exceeded			D,A,I=0		Detected		Exceeded
Average	1992		< 0.5	< 0.7	< 1.0	< 0.02	< 0.03
High	1992		< 0.5	< 0.7	< 1.0	< 0.02	< 0.03
Low	1992		< 0.5	< 0.7	< 1.0	< 0.02	< 0.03
N Samples	1992		7	4	12	12	12
Objectives	1992		Not	Not	Not	Not	Not
Exceeded			Exceeded	Exceeded	Detected	Detected	Exceeded
Average	1993		0.6	< 0.7	< 1.0	< 0.02	< 0.03
High	1993		1.4	< 0.7	< 1.0	0.02	< 0.03
Low	1993		0.5	< 0.7	< 1.0	< 0.02	< 0.03
N Samples	1993		12	12	12	12	12
Objectives	1993		I=1	Not	Not	Detected = 3	Not
Exceeded			D,A,I=0	Exceeded	Detected		Exceeded
Average	1994		< 0.5	< 0.7	< 1.0	< 0.10	< 0.03
High	1994		< 0.5	< 0.7	< 1.0	0.31	< 0.03
Low	1994		< 0.5	< 0.7	< 1.0	< 0.02	< 0.03
N Samples	1994		7	7	7	7	7
Objectives	1994		Not	Not	Not	Detected = 5	Not
Exceeded			Exceeded	Exceeded	Detected		Exceeded
Average	1995		< 0.5	< 0.7	< 1.0	< 0.03	< 0.03
High	1995		< 0.5	< 0.7	< 1.0	0.05	< 0.03
Low	1995		< 0.5	< 0.7	< 1.0	< 0.02	< 0.03
N Samples	1995		12	12	12	12	12
Objectives	1995		Not	Not	Not	Detected = 3	Not
Exceeded			Exceeded	Exceeded	Detected		Exceeded
Average	1996		< 0.5	< 0.7	< 1.0	< 0.24	< 0.03
High	1996		< 0.5	< 0.7	< 1.0	0.91	< 0.03
Low	1996		< 0.5	< 0.7	< 1.0	< 0.02	< 0.03
N Samples	1996		10	10	10	10	10
Objectives	1996		Not	Not	Not	Detected = 3	Not
Exceeded			Exceeded	Exceeded	Detected		Exceeded
Average	1997	< 0.1	< 0.3	< 0.6	< 0.6	< 0.19	< 0.03
High	1997	< 0.2	< 0.5	< 0.7	< 1.0	0.79	< 0.03
Low	1997	< 0.1	< 0.1	< 0.5	< 0.2	< 0.02	< 0.03
N Samples	1997	6	12	12	12	12	12
Objectives	1997	Not	Not	Not	Not	Detected = 4	Not
Exceeded		Exceeded	Exceeded	Exceeded	Exceeded		Exceeded
Average	1998	< 0.1	< 0.1	< 0.5	< 0.2	< 0.05	< 0.03
High	1998	< 0.1	< 0.1	< 0.5	< 0.2	< 0.05	< 0.03
Low	1998	< 0.1	< 0.1	< 0.5	< 0.2	< 0.05	< 0.03
N Samples	1998	6	6	6	6	6	6
Objectives	1998	Not	Not	Not	Not	Not	Not
Exceeded		Exceeded	Exceeded	Exceeded	Exceeded	Detected	Exceeded
Average	1999	< 0.1	0.6	< 0.5	< 0.2	< 0.05	< 0.03
High	1999	< 0.1	1.5	< 0.5	< 0.2	< 0.05	< 0.03
Low	1999	< 0.1	0.1	< 0.5	< 0.2	< 0.05	< 0.03
N Samples	1999	3	3	3	3	3	3
Objectives	1999	Not	I=2	Not	Not	Not	Not
Exceeded		Exceeded	D,A,I=0	Exceeded	Exceeded	Detected	Exceeded
Objectives							
Public Health							
Drinking Water (D)			10	1		Unlisted	45
Recreation (R)							
Aquatic Life (A)		4	0.6		0.24		0.2
Irrigation (I)			10				
Greenhouse (GI)							
Field Crop (FI)							
Livestock (L)		100	10		230		45
Promotes Nuisance Plants (P)							

Used for CWQI

Canadian Water Quality Index